# MODELLING CONGRESSIONAL DECISION MAKING FOR DEFENSE SPENDING

Stephen Carl Wood

# NAVAL POSTGRADUATE SCHOOL

## Monterey, California

# THESIS

MODELLING CONGRESSIONAL DECISION MAKING

FOR DEFENSE SPENDING

by

Stephen Carl Wood

March 1975

Co-Advisors: J.R. Capra and R.R. Judson

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle) Modelling Congressional Decision Making for Defense Spending | | 5. TYPE OF REPORT & PERIOD COVERED Master's Thesis; March 1975 |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s) Stephen Carl Wood | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940 | | 12. REPORT DATE March 1975 |
| | | 13. NUMBER OF PAGES 154 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) Naval Postgraduate School Monterey, California 93940 | | 15. SECURITY CLASS. (of this report) Unclassified |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Regression Analysis
Least-Squares Regression
Congressional Appropriations
Defense Budgeting
Davis, Dempster, Wildavsky Model

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The intent of this thesis is to investigate the decision making mechanism whereby Defense funding levels are determined. To accomplish this, simple linear decision models similar to those employed by Davis, Dempster, and Wildavsky for the non-defense appropriation process are used in analyzing Congressional responses to Department of Defense budget

Block 20 - ABSTRACT (Cont.)

requests. Defense budgetary data for the Fiscal 1953-1971 time frame are empirically tested via time-series and cross-sectional linear regression analysis for Procurement and RDT&E. Results are tabulated and discussed. Model strengths as well as weaknesses are evaluated based on their statistical properties and level of data aggregation. Significant results are summarized and areas for further study suggested.

Modelling Congressional Decision Making

for Defense Spending

by

Stephen Carl Wood
Lieutenant, United States Navy
B.S., University of Iowa, 1967

Submitted in partial fulfillment of the
requirements for the degrees of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

and

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
March 1975

## ABSTRACT

The intent of this thesis is to investigate the decision making mechanism whereby Defense funding levels are determined. To accomplish this, simple linear decision models similar to those employed by Davis, Dempster, and Wildavsky for the non-defense appropriation process are used in analyzing Congressional responses to Department of Defense budget requests. Defense budgetary data for the Fiscal 1953-1971 time frame are empirically tested via time-series and cross-sectional linear regression analysis for Procurement and RDT&E. Results are tabulated and discussed. Model strengths as well as weaknesses are evaluated based on their statistical properties and level of data aggregation. Significant results are summarized and areas for further study suggested.

TABLE OF CONTENTS

## LIST OF FIGURES

Figure

Figure

Figure

# I. INTRODUCTION

One of the more notable outcomes of the Vietnam conflict is the increased dissatisfaction with defense policies and growing public demands to reorder national priorities. Of particular concern to the nation's taxpayers is the manner in which the Congress determines the annual budget for the many governmental agencies. Numerous methodologies have been employed by political scientists to describe the budgetary process; one of these being through a series of simple, linear, stochastic models. These attempts at description have been more or less successful depending upon the premise being investigated and the level of data aggregation used.

Studies of the Congress conducted by political scientists Richard F. Fenno, Aaron Wildavsky, and the team of Davis, Dempster and Wildavsky are generally regarded as the theoretical basis for most of the analyses being done today. By interviewing numerous appropriations committee members and observing committee behavior toward budget requests, Fenno and Wildavsky were able to document apparent Congressional appropriation procedures and personalities. Using this documented behavior Davis, Dempster and Wildavsky proposed a series of simple, linear, stochastic models to empirically test their hypothesis that the federal budgetary process could be modelled by simple (basically incremental) decision rules. In a series of published reports Davis, Dempster and

Wildavsky focused their attention on time-series analysis of Congressional behavior toward selected non-defense agency budget requests. The data used for their studies covered a period of 16 years (1947-1963) and was taken from records of agency requests and subsequent Congressional action on these requests. From their studies Davis et al. were able to conclude that Congressional behavior toward non-defense budget requests did, in fact, appear to follow their postulated decision rules [Ref. 11].

Criticism of the Davis, Dempster and Wildavsky studies has centered around the following issues:

1. the models describe the outcome of the budgetary process and not the process itself [Ref. 35];

2. possibly, Davis et al. should have examined request and appropriations at a lower level of aggregation rather than total agency proposals and appropriations [Ref. 24];

3. the studies say nothing about programs [Ref. 31].

In response to this criticism, Johnson [Ref. 24] examined various non-defense agency budget requests in terms of objects of expenditures (Personal Services, Travel, Equipment, etc.). Citing Fenno's work in Congressional-agency relationships and selected works in organizational theory, Johnson formulated a series of simple, linear, stochastic models of agency requests based on increments in the requests for the years 1949-1960. As a result of his analysis Johnson concluded that:

> "Agencies can be described as conforming to the patterns established by previous Bureau of the Budget and Congressional actions on their requests." [Ref. 24, p. 22]

Noting that they had neglected to include the Department of Defense in their studies Davis, Dempster, and Wildavsky stated that "there is no reason to believe that these models are not equally applicable to the defense appropriations process" [Ref. 1, p. 301]. Arnold Kanter disputed this claim. From his studies of Congressional reaction to defense budget requests in the period 1960-1970 Kanter concluded that the Davis, Dempster, and Wildavsky results were applicable only to non-defense agencies since, unlike the defense budget, a majority of non-defense expenditures are uncontrollable (fixed by statute and/or trust and not subject to annual review) by the Congress and few new projects are introduced by the agencies [Ref. 26, p. 129-143].

Stromberg [Ref. 36] has used the Davis, Dempster, and Wildavsky idea of linear, stochastic decision models to describe the defense appropriations process for the years FY1953-1968. Focusing mainly on describing the decision making process for the various actors in the defense budgetary cycle (agency, Bureau of the Budget, House and Senate Appropriations Subcommittees), Stromberg's study does provide some evidence that the Davis et al. concept of simple, linear, stochastic decision models has merit for DoD-Congressional interaction.

The objective of this thesis is to directly apply the concept of simple, linear (basically incremental) decision rules -- similar to those postulated by Davis, Dempster, and Wildavsky -- to Congressional behavior toward DoD budget

requests for RDT&E and Procurement. When examing agency and Congressional behavior with respect to DoD budget requests in RDT&E and Procurement, it is possible to focus on total budgets and/or on the items within these budgets. In this study the full range of data aggregation - from total RDT&E and Procurement budgets to program elements within these budgets-will be subjected to analysis. After fitting a series of postulated decision models to each aggregation level consideration will be given to determing which models realize the best fit for the data.

The actual organization of the analysis includes background on the defense budgetary process during which an effort will be made to identify the roles and impact of the Congress. This section is followed by chapters on model description, criteria for testing the significance of a model and/or its coefficients, and empirical results with emphasis on identifying those models with greatest descriptive potential. Finally, the significance of the empirical results are discussed and areas for further study are suggested.

# II. BACKGROUND

This section is designed to provide an understanding of the defense budgetary cycle, both before and after the introduction of PPBS (Planning, Programming, and Budgeting System) into the Department of Defense's planning process. A detailed chronology of a defense budget cycle is given with emphasis placed on identifying the roles played by the services (as members of the Defense Department), the Department of Defense (as a Federal agency) and the Congress (a decision maker for appropriations matters). Finally, current literature on budgetary matters is reviewed to provide an understanding of the theoretical basis for using simple, linear (basically incremental) decision models to describe the budgetary process.

## A. DEFENSE BUDGETING PRIOR TO 1961

Prior to 1961, the level of defense spending was determined (except in times of war) by what has been described as the "budget ceiling" approach. The President would indicate the general level of defense spending which he felt was appropriate for the international climate and his economic and fiscal policies. The Secretary of Defense would then allocate this figure among the military departments. Each military department would in turn prepare the basic budget submission, allocating its portion of the military budget among its functions, units, and activities. Additional

funding requests were also submitted for those activities imperative to national defense which could not be accommodated within the basic budgetary needs in what has become known as the "B" list (for example, the Navy's Polaris Program). Then all of the budget submissions were reviewed together by the Secretary of Defense.

The consequences of such fiscal planning are fairly obvious. Each service tended to exercise its own priorities, favoring its own unique missions to the detriment of the joint military mission. They (services) strived to establish the groundwork for an increased share of future budgets by concentrating on new weapons systems while protecting the present sizes of their forces. Moreover, because attention was focused on only the upcoming fiscal year, the individual services had every incentive to propose new systems, the full costs of which would only be realized in subsequent years.

Another detrimental aspect of this method of budgeting was the almost complete separation of budgeting and planning. These critically important functions were performed by two different groups; planning by the military establishment and budgeting by the civilian secretaries of defense. As a result, the Secretaries found that decisions on force levels and programs had to be made on the basis of little information within a period of a few weeks allocated for budget review near the end of the budget cycle. Moreover, each year the plans and programs provided by the services had to be

cut back to fit within the President's budget ceiling established for that fiscal year. Beyond that budget, plans continued to be formulated with the hope that the next year's ceiling would be higher [Ref. 23].

## B. DEFENSE BUDGETING, 1961 TO THE PRESENT - THE PPBS CYCLE

To streamline defense budgeting the concept of program budgeting was integrated into the Defense Department's fiscal planning process. In the context of program budgeting, the program was meant to be the basic planning unit that would bring together all of the resources required for a specific mission. While the actual mechanics of the present planning cycles differ somewhat from those established in the early sixties, the basic philosophy of program budgeting has remained the same. The following is a summary of the present process.

Prior to formal budget submission to the Congress as an integral part of the total Federal budget, the DoD budget undergoes approximately 18 months of development and review within the Defense Department. The preparation process, known as the Planning, Programming and Budgeting System or PPBS, includes three distinct phases: planning (six months); programming (nine months); and budgeting (three months).

The planning phase primarily involves threat analysis and force level requirements determination to counter these threats, first unconstrained by cost and then under tentative fiscal constraints established by the Office of the Secretary of Defense (OSD). Once the views of the National

Security Council, the Joint Chiefs of Staff, and SECDEF on desired force levels have been examined and evaluated a Joint Force Memorandum or JFM is formulated and distributed to the services [Ref. 4].

Receipt of the JFM by the services officially signals the beginning of the programming phase. In a continuous dialogue between OSD and the services the manpower, weapon system and resource requirements necessary to obtain and maintain those forces as outlined in the JFM are considered. At the end of this phase OSD provides the services with Program Decision Memorandums which review all relevant opinions and decisions of OSD on military needs for the next five years. The end product of the programming phase is the Five Year Defense Plan (FYDP) which contains DoD's updated list of programs, program elements, force levels and attendant resources for the ensuing fiscal year and the following four years. It should be noted that this phase emphasizes programs through coordination by SECDEF across service lines and the determination and evaluation of tradeoffs among programs and program elements.

The final phase, budgeting, occurs during the period from October through December immediately preceding submission of the budget to the Congress in January. Up to this point the budget has been considered in program format and must now be transformed into appropriation categories before being submitted to the Congress. This transformation (known as crosswalking) is the process by which resources needed to

support the program elements are aggregated into appropriation categories. As an illustration of this process, consider Figure 1. Determination of MILITARY PERSONNEL requirements-NAVY (MPN) involves going through all program elements in the Navy budget and summing their individual MILITARY PERSONNEL resource requirements. This sum represents the total Navy MILITARY PERSONNEL funding needs. A similar procedure is followed to determine the other appropriation category requirements. A complete breakdown of Major Defense Programs and Congressional Appropriation Categories is included as Figure 2.

Once the program needs are crosswalked into the various appropriation categories they are forwarded to OSD and the Office of Management and Budget (OMB) for review and integration into the President's Federal budget and subsequent submission to the Congress.

Completion of the formal PPB cycle in no way marks the end of DoD's consideration of its budget request. In reality, submission of the budget to Congress signifies the beginning of a new dialogue; this time between the Congress and the Department of Defense. During the Authorization and Appropriation Committees' review of the defense budget a request for additional information on a specific line item (for example, Navy A-7E Attack Aircraft) or the impact of a reduction in funding for an entire program will generate further analyses of that line item by OSD or the service involved. This question and answer process tends to reveal

Figure 1

"Crosswalking" the Defense Budget into Congressional Appropriation Format, an example of

**NAVY BUDGET**

PROGRAM I - Strategic Forces

Program Element: Polaris

| | |
|---|---|
| Military Personnel | $XXXX |
| Operations & Maintenance | $XXXX |
| Procurement | $XXXX |
| . | . |
| . | . |
| . | . |
| Total Requirements-Polaris = | $XXXX |
| . | . |
| . | . |
| . | . |
| Total Requirements Strategic Forces = | $XXXX |

PROGRAM II - General Purpose Forces

Program Element: F-14 Squadrons

| | |
|---|---|
| Military Personnel | $XXXX |
| Operations & Maintenance | $XXXX |
| Procurement | $XXXX |
| . | . |
| . | . |
| . | . |
| Total Requirements - F14 = | $XXXX |
| . | . |
| . | . |
| Total Requirements - General Purpose Forces = | $XXXX |

PROGRAM III - Intelligence & Communications

| | |
|---|---|
| . | . |
| . | . |
| Total Navy Requirements = | $XXXX |

**CONGRESSIONAL BUDGET**

MILITARY PERSONNEL

| | |
|---|---|
| Army | $XXXX |
| Navy | $XXXX |
| Air Force | $XXXX |
| Marine Corps | $XXXX |
| Total Military Personnel= | $XXXX |

OPERATIONS & MAINTENANCE

Army

Navy

Air Force

Marine Corps

Total Operations & Maintenance

PROCUREMENT AIRCRAFT & MISSILES

Army

Navy

.

.

.

Total Defense Budget

Figure 2

Major Defense Programs and Congressional Appropriation Categories; a listing of

A. MAJOR DEFENSE PROGRAMS

O(Zero)- Support of Other Nations
I ------ Strategic Forces
II ----- General Purpose Forces
III ---- Intelligence & Communications
IV ----- Airlift & Sealift
V ------ Guard & Reserve Affairs
VI ----- Research & Development
VII ---- Central Supply & Maintenance
VIII --- Training, Medical & Other Personnel Activities
IX ----- Administration & Associated Activities

B. CONGRESSIONAL APPROPRIATION CATEGORIES

| | Obligational Period |
|---|---|
| Research, Development, Test and Evaluation | 2 years |
| Procurement (except Shipbuilding and Conversion) | 3 years |
| Shipbuilding and Conversion | 5 years |
| Military Construction | 2 years |
| Military Personnel | 1 year |
| Reserve Personnel | 1 year |
| Operations and Maintenance | 1 year |

the strengths or weaknesses of a request and the underlying desires of Congress.

Congress is supposed to review and appropriate funds based on a submitted budget before the beginning of the new fiscal year. However, since the late 1960's, it has not been unusual for the authorization and appropriation hearings on major programs in the defense budget to last more than six months (for example, the FY 1974 Defense Appropriation Bill was finally reported out of Committee in late December some six months after the beginning of the fiscal year). When it is apparent that legislative consideration of the defense budget cannot be completed prior to the beginning of the fiscal year a continuance in funding is generally granted for those programs already in existence at the levels prescribed by the previous appropriation bill.

Each step of the legislative review process serves to limit or constrain final funding levels. The defense budget first goes to the House and Senate Armed Services Committees for authorization action where an upper limit is established on funding for each program and program elements. Military Personnel, Operations and Maintenance, and part of Procurement have a continuing authorization and, as such, are not reviewed by these committees. Annual authorization action has been required for procurement of aircraft, missiles, or naval vessels since December 31, 1960; Research, Development, Test and Evaluation (RDT&E) since FY 1963; Tracked Combat Vehicles since FY 1968; Other Weapons since FY 1970; and

Torpedoes since FY 1971. Legislative procedure requires that the House and Senate pass separate Authorization Bills. If the bills, as passed, are not identical joint conference action is required to remove existing differences. The resulting Authorization Bill is then passed to the respective House and Senate Defense Appropriation Subcommittees for determination of actual funding levels (final appropriations must be within the upper limits established by the Authorization Bill). Separate hearings are held by these subcommittees during which line item requests are reviewed with key witnesses from the Services. Particular attention is directed towards determining the need for and relative worth of a weapon system in light of total defense needs. The final Defense Appropriation Bill, when reported out of committee, delineates the level of New Obligational Authority (NOA) allocated to the appropriation categories and represents an upper limit to which the Federal Government may be obligated by the Defense Department during the obligational period associated with a specific appropriations category (see Figure 2 for lengths of obligational periods).

The final phase of the budget cycle is conducted by the Services after the defense budget is signed into law by the President. During this phase the Congressional allocations to the appropriation categories are crosswalked back into Defense budget format. If a specific program element has been cut by the Congress then that program is funded accordingly. To allocate undistributed reductions in funding,

decisions must be made as to which programs and/or program elements are to be affected. Once these decisions have been made the budget cycle is complete.

While the defense budget has been portrayed as a sequence of distinct phases it is, in reality, a continuim of inter-dependent events. At any one time there are several Fiscal Year budgets being considered and decisions/inquiries relevant to one impacts upon the others. Changing assessment(s) of future threats by the Congress or JCS creates an atmosphere of uncertainty in which the military organizations must plan for their future needs. The means by which a degree of stability is created within this uncertainty forms the theoretical basis for the Davis, Dempster and Wildavsky models and is discussed next.

## C. BUDGETING LITERATURE REVIEW

Behaviorists have divided the environmental field into four basic fields: (1) placid, randomized; (2) placid, clustered; (3) disturbed reactive; and (4) dynamic-turbulent [Ref. 10, p. 435-447]. While each of these four types describe the characteristics of the relationship between a type of environmental setting and organizational behavior the dynamic-turbulent best describes that of Federal agencies and bureaus. Federal agency budgets are influenced not only by interactions between agencies and other organizations such as OMB and the Congress, but also by societal and world events.

Characteristic of the dynamic-turbulent environment is the degree of uncertainty in which organizations must function and the manner in which this uncertainty is reduced to an acceptable level. In their studies of organizational behavior Cyert and March found that organizations attempted to reduce uncertainty by relying less on long-range planning and more on short-run reaction to feedback from the environment and by attempting to establish a receptive (or at least a predictable) environment [Ref. 10].

Fenno and Wildavsky noted this type of behavior in their studies of Congressional/non-defense agency interaction. Fenno, in The Power of the Purse, asserts that agencies have certain expectations about the budgetary process; they expect fair play, that is, to receive the same treatment as other agencies; they desire to have their budget requests evaluated on the merits of program activities. Also, agencies attempted to reduce funding uncertainty by maintaining stable relationships with the Congressional Appropriation Committees in order to minimize conflict. Budget reductions naturally hurt the agencies but agency officials felt that their activities were hurt more by not knowing what the other participants in the budgetary process would do from year to year or why they behaved the way they did [Ref. 20, p. 273].

Feelings of uncertainty and the maintenance of expectations were not confined solely to the agencies. George H. Mahon, Chairman of the Subcommittee on the Department of Defense, Committee on Appropriations, House of Representatives summed up committee uncertainty when he stated:

"No human being regardless of his position and capacity could possibly be completely familiar with all of the items of appropriations contained in a defense bill." [Ref. 20, p. 10].

In his interviews with committee officials, Fenno found that Congress felt that agencies should treat the public fairly; that they should have some understanding of the Congress, the work of the committees and the individual committee members and; that the agencies should be "frank and open and not attempt to cover-up or hold back relevant information" in their dealings with the Congress [Ref. 20, p. 320].

Based on their interviews and observations of the budgetary process, Davis, Dempster and Wildavsky felt that it was not unreasonable to hypothesize that Congressional reaction to a submitted budget might best be explained by a model (or series of models) that were simple and stable over time. Furthermore, based on agency expectations that the Appropriation Committees accept its basic or core programs and focus on the additional increment being requested for that year, some form of linear model was assumed. This assumption appears to be reasonable in that Fenno also noted that:

"Just as the agency considers much of its request to be beyond controversy, so too does the committee act on this assumption by restricting its purview to those budgetary increments granted in the previous year and requests for the coming year." [Ref. 20, p. 318].

While their empirical analyses were confined entirely to non-defense federal agencies, Fenno and Wildavsky's studies appear to be applicable to the budgetary process in general.

This plus the fact that a majority of Defense Subcommittee members also sit on non-defense subcommittees makes it reasonable to assume that their concept of simple, linear (basically incremental) decision rules is equally valid for the defense appropriations process.

## III. MODEL DESCRIPTION

The models suggested in this thesis for Congressional behavior when considering DoD budget requests are similar to those used by Davis, Dempster and Wildavsky to describe the Congressional/non-defense agency budgetary process. Their basic structure suggests a set of possible decision rules that are linear, stable over periods of time, stochastic, and strategic in nature. In reality, they may be thought of as "as if" models in that realizing a good fit for a given model means only that the actual behavior of the participants appears to follow the relationship suggested by the model. The models do not attempt to describe the decision making process in minutiae but rather in an input-output sense where the President's budget submission may be considered to be the input variables and final Congressional appropriations as the output quantity.

For each model the constant term, normally found in a linear model, is suppressed in order to interpret the coefficient(s) as increments or percentage figures. Although intuitively appealing, models of this type have somewhat different statistical properties and thereby present some difficulty in empirical testing and evaluation (see Chapter IV). Each model also contains a random error term which accounts for events that might otherwise upset the simplicity of the model. Davis, Dempster, and Wildavsky describe such events in the following manner:

"Occasionally, world events take an unexpected turn, a new President occupies the White House, some agencies act with exceptional zeal, others suffer drastic losses of confidence on the part of the appropriations subcommittees, and so on." [Ref. 11, p. 531].

For each of the models the following definition of variables apply:

$X_t$ - agency funding request in year t as contained in the President's budget

$Y_t$ - final Congressional appropriations for a given request in year t. Supplemental appropriations are not included[1]

$X_{t-1}$ - agency funding request in year t-1

$Y_{t-1}$ - final Congressional appropriations for a request in year t-1

$\varepsilon_t$ - stochastic error or disturbance term. $\varepsilon_t$ is usually assumed to be normally distributed with mean zero and constant variance with the sequence ($\varepsilon_t$) being independently and identically distributed random variates

## A. SERVICE DECISION MODELS

Before attempting to model Congressional reaction toward a submitted defense budget it is necessary to investigate different possible strategies that the services may be using to formulate their requests, for the Congress may know the specific decision rule being used by the services and react accordingly.

The first model attempts to describe a service's behavior when, though convinced of the worth of its programs, it

---

[1] It is felt that omitting supplemental budget requests will not significantly distort study results. In the more recent years supplemental requests have been used as a "launching point" for new projects (for example, the Navy's Patrol Frigate) and if accepted in the supplemental budget these projects are included in the next year's main budget.

realizes that extraordinarily large or small requests tend to precipitate unfavorable Congressional reaction. Therefore, in an effort to secure the necessary funding while avoiding suspicion, the agency will tend to request a percentage of the previous year's appropriation. This percentage will be stable over time. However, favorable (unfavorable) events may generate requests that are larger (smaller) than normally submitted. Decisions made in this manner may be represented mathematically as:

$$X_t = \beta_0 Y_{t-1} + \varepsilon_t \qquad \text{(R1)}$$

where $\beta_0$ represents the percentage of the previous appropriation requested and $\varepsilon_t$ the random error term.

The second request model attempts to explain the actions of the service that is convinced of the worth of its programs regardless of previous Congressional action. This type of behavior is especially appealing when the Congress has confidence in the agency and tends to appropriate amounts equal to or greater than the requests submitted. Accordingly, the annual request for such a program should be a fairly stable percentage of the previous year's request plus an error term. Thus

$$X_t = \beta_1 X_{t-1} + \varepsilon_t \qquad \text{(R2)}$$

may be used to investigate such behavior. In the absence of exogenous events, the request in year t should be greater than the request in the previous year (t-1).

Finally, a service may desire to smooth out its stream of appropriations by taking into account the difference between its request and appropriation in the previous year. This difference may be thought of as a barameter -- an indication of how well past request(s) have been received in order to determine which areas to emphasize in the present budget. Such behavior may be expressed as

$$X_t = \beta_2 Y_{t-1} + \beta_3 (Y_{t-1} - X_{t-1}) + \varepsilon_t \qquad \text{(R3)}$$

where $\beta_2$ represents the percentage of the previous year's appropriation being requested and $\beta_3$ the percentage difference between last year's appropriation and request desired.

## B. CONGRESSIONAL[2] DECISION MODELS

In order to investigate the many possible decision strategies that the Congress may have used in determining funding level a series of models were postulated. Each model attempts to link expressed Congressional feelings and desires with possible behavior.

The first model considers Congressional response to a defense agency to be a function of that agency's request. This type of behavior may result if the Congress feels that the agency's requests are realistic and, as a result, a fairly stable indication of that agency's needs to carry out

---

[2] In the context of this study "Congressional" means the aggregate authorization and appropriation committees impact on the Defense budget.

existing and planned programs. Should this be the case then Congress may respond by appropriating a relatively fixed percentage of the request. Such behavior may be expressed mathematically as

$$Y_t = \alpha_0 X_t + \varepsilon_t \tag{A1}$$

where $\alpha_0$ represents the percentage appropriated and $\varepsilon_t$ the stochastic error term.

Next, suppose that although Congress usually grants a fixed percentage of the agency request, it sometimes happens that this amount represents an expenditure which extends the agency's programs either above or below the size desired by Congress. Such a situation could result when an agency follows Presidential aims which differ significantly from those of the Congress. In this situation Congress may appropriate a sum different from its usual percentage. Then, in the following year, should agency and Congressional aims become more aligned ($X_t$ approximately equal to $Y_{t-1}$) the Congress may attempt to make allowances for the deviation out of the current year appropriation. If $\alpha_1$ represents the usual percentage appropriated then

$$Y_t = \alpha_1 X_t + \nu_t$$

may be used to describe such behavior; where $\nu_t$ is the stochastic disturbance term that takes on unusually large positive or negative values in accordance with the first order Markov scheme

$$\nu_t = \alpha_2 \nu_{t-1} + \varepsilon_t$$

Substitution results in

$$Y_t = \alpha_1 X_t + \alpha_2 (Y_{t-1} - \alpha_1 X_{t-1}) + \varepsilon_t \qquad (A2)$$

the second Congressional decision model.

Finally, specialization by subcommittee members allows some members of Congress to have substantial knowledge of the military services and their budget formulation. This knowledge may aid the appropriation subcommittees in identifying the decision model used by the services to formulate their request or proposed program expansion for a given year. For example, if Congress knows that decision model R1 was used to formulate agency requests then the subsequent appropriation decision model may include this information. The model

$$Y_t = \alpha_3 X_t + \alpha_4 \lambda_t + \varepsilon_t$$

may be used to describe such behavior when $\lambda_t = X_t - \beta_0 Y_{t-1}$. Substitution for $\lambda_t$ provides for the third decision model

$$Y_t = \alpha_3 X_t + \alpha_4 (X_t - \beta_0 Y_{t-1}) + \varepsilon_t \qquad (A3)$$

On the other hand, should the appropriation committee members be concerned with program expansion rate the expression

$$Y_t = \alpha_5 X_t + \alpha_6 (X_t - X_{t-1}) + \varepsilon_t \qquad (A4)$$

may best describe such concern. The variable $(X_t - X_{t-1})$ should provide a reasonable indication of agency desires to expand or reduce its sphere of influence in a particular field.

The series of models postulated for this study of Congressional-DoD interaction in no way exhausts the list of possible models.[3] They are, however, consistent with the data available and maintain the concept of incrementalism and simple decision rules suggested by Davis, Dempster, and Wildavsky. It should be noted that these models do not distinguish between actions initiated by the House and Senate Armed Services Appropriations Committees. For studies of these committees see Fenno [Ref. 19] and Lukenas [Ref. 28].

---

[3] Numerous other models were examined in preliminary testing-Congressional decision rules similar to A3 but with R2 and R3 as the agency decision rule, log-linear analogs of all the previously described models, and several so called "agency base" models to list a few. Test results for Congressional decision model A3 with R2 and R3 as the agency request strategy indicated that the gaming coefficient was statistically insignificant. For the log-linear models little improvement in predictive power was noted.

# IV. MODEL SELECTION CRITERION

Davis, Dempster, and Wildavsky have used adjusted coefficient of determination ($\overline{R}^2$) to judge the adequacy of the fit of a model to the data [Ref. 11, p. 274]. Stromberg has noted that there are methodological problems with linear regression without a constant term and that "$R^2$ is not an especially desirable measure of goodness fit." As an alternate measure of model fit Stromberg proposed the use of "$W^2$ or proportion of variation explained" [Ref. 36, p. 21-24]. This author believes that only "the tip of the iceberg" has been noted and that other methodology problems may exist when evaluating linear regression models with a suppressed constant term.

To acquaint the reader with the methodological differences between linear regression with and without a constant term a general review of linear regression theory for models with a constant term and its validity for models with a suppressed constant is included in part A. Part B documents those statistical tests to be used for testing and evaluation of the models proposed in the previous chapter. Particular attention is given to identifying the impact of suppressing the constant term on test validity. Finally, part C discusses selected nonparametric criteria that were employed when necessary parametric assumptions were questionable.

## A. LINEAR REGRESSION THEORY

### 1. Linear Regression with a Constant Term

Suppose that there are n observations $(X_t, Y_t)$, $(X_{t+1}, Y_{t+1}), \ldots, (X_{t+n}, Y_{t+n})$ where $X_t$ is defined as the independent variable and $Y_t$ the dependent variable. Further suppose that after plotting these n observations a linear relationship of the form

$$Y_t = \beta_0 + \beta_1 X_t + \varepsilon_t \; ; \quad t=1, \ldots, n \tag{1}$$

where: $Y_t$ and $X_t$ are as previously defined

$\beta_0$ = the constant term (intercept coefficient)

$\beta_1$ = the slope coefficient

$\varepsilon_t$ = random error term (difference between actual and estimated value of $Y_t$)

is postulated. The sum of squares of deviations from the regression line is

$$S = \sum_{i=1}^{n} \varepsilon_t^2 = \sum_{i=1}^{n} (Y_t - \beta_0 - \beta_1 X_t)^2 . \tag{2}$$

The objective of least-squares regression is to select $\hat{\beta}_0$ and $\hat{\beta}_1$ (estimators of $\beta_0$ and $\beta_1$) to be those values which, when substituted for $\beta_0$ and $\beta_1$, produce the least possible value of S. These values may be determined by differentiating equation (2); first with respect to $\beta_0$ and then $\beta_1$ and setting these results equal to zero. The solution to the two resulting equations (called Normal equations) is

$$\hat{\beta}_1 = \frac{\sum_{t=1}^{n} X_t Y_t - [(\sum_{t=1}^{n} X_t)(\sum_{t=1}^{n} Y_t)]/n}{\sum_{t=1}^{n} X_t^2 - (\sum_{t=1}^{n} X_t)^2/n} \qquad (3)$$

and $$\hat{\beta}_0 = \overline{Y} - \hat{\beta}_1 \overline{X} \ . \qquad (4)$$

Up to this point no assumptions that involve probability distributions have been made. If it can be assumed that, in equation (1)

a. $\varepsilon_t$ is a random variable with mean zero and constant variance $\sigma^2$ (unknown); and

b. $\varepsilon_t$ and $\varepsilon_{t+i}$ are uncorrelated, $i \neq 0$

then the Gauss-Markov theorem insures that the least-squares estimators $\beta_0$ and $\beta_1$ are minimum variance, unbiased estimators in the class of estimators that are linear in the observations.

If it is further assumed that the $\varepsilon_t$'s are

c. independently, identically distributed normal random variates with mean zero and variance $\sigma^2$, that is, $\varepsilon_t \sim N(0,\sigma^2)$

then $\hat{\beta}_0$ and $\hat{\beta}_1$ achieved the Cramer-Rao lower bound for variance of an estimator [Ref. 25, p. 8-33].

2. Linear Regression without a Constant Term

If, instead of equation (1), suppose that the relationship

$$Y_t = \beta_1 X_t + \varepsilon_t \ ; \quad t=1,\ldots,n \qquad (5)$$

is postulated for the data. The sum of squares of deviations from the regression line then becomes

$$S' = \sum_{t=1}^{n} \varepsilon_t^2 = \sum_{t=1}^{n} (Y_t - \beta_1 X_t)^2 \tag{6}$$

Minimization of S' yields only one Normal equation from which the estimator for $\beta_1$ may be derived.

$$\hat{\beta}_1 = \frac{\sum_{t=1}^{n} X_t Y_t}{\sum_{t=1}^{n} X_t^2} . \tag{7}$$

Since there is but one Normal equation, the sum of the error terms ($\sum_{t=1}^{n} \varepsilon_t$) may or may not equal zero for linear regression without a constant.

The importance of this result becomes apparent when reviewing the assumptions outlined in section A1. If the regression line naturally passes through the origin then $\beta_0$ and $\sum_{t=1}^{n} \varepsilon_t$ will be zero. If, however, the regression line does not pass through the origin and the constant term is suppressed then $\sum_{t=1}^{n} \varepsilon_t$ will not be zero. Should this be the case, the validity of assumptions a, b, and c is questionable.

## B. STATISTICAL CRITERIA FOR TESTING LINEAR REGRESSION MODELS

### 1. Significance of Estimated Coefficients

The t-statistic is used to test the statistical significance of a coefficient and is defined as the ratio of the difference between the coefficient's estimated and hypothesized value and its standard error; that is

$$t = \frac{\hat{\beta} - \beta}{\hat{\sigma}_{\hat{\beta}}}$$

[Ref. 25, p. 37]. Theoretically the error terms need to be normally distributed with mean zero and constant variance. However, there are simulations which have shown "t" to be fairly robust towards distributional assumptions. Therefore, the "t" test will be considered valid for linear models with a suppressed constant.

2. Coefficient of Determination

Coefficient of determination or $R^2$ is a standard measure of "goodness of fit" for linear regression models and is defined as the proportion of (sample) variance (in the dependent variable) explained by the fitted regression line. When all of the dependent variable observations in the sample coincide with the least-squares regression estimates $R^2$ equals one, a perfect fit. As the proportion of total variance that remains unexplained increases $R^2$ approaches zero.

The usual computational formula for estimating $R^2$ for a data sample is

$$R^2 = 1 - \frac{\sum_{t=1}^{n}(Y_t - \hat{Y}_t)^2}{\sum_{t=1}^{n}(Y_t - \overline{Y})^2}$$

$$= 1 - \frac{\text{unexplained variance of the dependent variable about the regression line}}{\text{total variance of the dependent variable about its mean}}$$

[Ref. 33, p. 45].

Replacing $(Y_t-\hat{Y}_t)^2$ by $\varepsilon_t^2$, the square of the error term for observation t, the formula for $R^2$ used here will be,

$$R^2 = 1 - \frac{\sum_{i=1}^{n} \varepsilon_i^2}{\sum_{i=1}^{n}(Y_i-\overline{Y})^2}$$

Stromberg [Ref. 36, p. 21-24] has pointed out that the interpretation of $\sum_{i=1}^{n} \varepsilon_i^2$ as the (sample) unexplained variance is not correct for linear regression models without a constant term since $\sum_{i=1}^{n} \varepsilon_i$ may or may not be zero. Injecting $\bar{\varepsilon}$ into the expression for $R^2$ will not help since one could theoretically obtain a high coefficient of determination when the average error about the regression line is large but the spread about this average is small.

Stromberg and the BIOMED statistical package [Ref. 14] have addressed this problem by computing a somewhat different statistic. They have computed, instead, what Stromberg defines as $W^2$ where

$$W^2 = 1 - \frac{\sum_{i=1}^{n} \varepsilon_i^2}{\sum_{i=1}^{n} Y_i^2}$$

$$= 1 - \frac{\text{unexplained variation of the dependent variable about zero}}{\text{total variation of the dependent variable about zero}} .$$

The problem with this measure of goodness of fit is that zero and not the regression line appears to have been chosen somewhat arbitrarily as the point about which the

variation in the dependent variable is computed. Also, if $\bar{\varepsilon}$ is equal to or near zero (which will be the case if the computed intercept using a standard linear regression approach is zero) then with a positive $\bar{Y}$ (which is always the case with budget data) $W^2$ may yield a value considerably larger than $R^2$ and may be misleading to someone thinking in terms of $R^2$.

3. <u>Standard Error of Estimate and Coefficient of Variation</u>

Another measure of dispersion about the regression line is the standard error of the estimate (SE) and may be determined by using the formula

$$SE = \sqrt{\frac{\sum_{i=1}^{n}(Y_i-\hat{Y}_i)^2}{n-k}}$$

where: n = the number of sample observations

k = the number of parameters being estimated in the regression

[Ref. 25, p. 129]. The numerical value of the standard error of estimate is inversely related to the goodness of fit of the model.

It is somewhat difficult, however, to determine the significance of the standard error of estimate when comparing different sets of data. For this reason it is useful to compute a relative standard error of estimate. The coefficient of variation (CV) is such a measure since it relates the standard error of a particular model to the mean value of the dependent variable, i.e.

$$CV = \frac{SE}{\overline{Y}}$$

A value of less than 0.20 for the coefficient of variation for a model is frequently cited as desirable [Ref. 33, p. 44]. One particularly desirable characteristic of both the standard error of estimate and coefficient of variation is that they are not dependent upon any distributional assumptions of the error terms.

## C. NONPARAMETRIC CRITERIA FOR TESTING LINEAR REGRESSION MODELS

### 1. The Mann-Whitney U Test

The Mann-Whitney U test may be used to test whether two data sets have been drawn from the same population and is useful when underlying distributional assumptions are questionable.

First, suppose that there appears to be two distinct sets of data; set A of size $n_1$ and set B of size $n_2$ ($n_1 < n_2$). To test the null hypothesis that both sets are from the same population the sample observations are pooled and ranked in order of increasing size. The value of the U statistic is computed by the formula

$$T = S - (n_1)(n_1+1)/2$$

where S = the number of times that an observation in data set B precedes an observation in set A [Ref. 6, p. 224]. If T is greater than the tabled value for $U_{(n_1, n_2)}$ for significance level $\alpha$ then the null hypothesis cannot be rejected.

2. Theil U-Statistic

The Durbin-Watson test and examination of residual plots provide insight into identifying problems of misspecification and bias, respectively. However, in the case of small samples (as in budget data for DoD and the agencies) these techniques are often inconclusive. Also, the Durbin-Watson test requires that the sum of the error terms equal zero.

As an alternative means of identifying bias and/or misspecification in a model with a suppressed constant term Theil's methodology for comparing estimates and actual observations was considered [Ref. 39, p. 19-32].

Theil uses the idea of mean square error (MSE) in defining an inequality coefficient U as

$$U = \sqrt{\frac{\frac{1}{n}\sum_{i=1}^{n}(P_i - A_i)^2}{\sum_{i=1}^{n} A_i^2}}$$

where: $A_i$ = the actual value of observation i

$P_i = \hat{A}_i$ (the predicted value of $A_i$)

Next, the numerator of U is decomposed in the following manner:

$$\frac{1}{n}\sum_{i=1}^{n}(P_i - A_i)^2 = (\overline{P}-\overline{A})^2 + (S_P - S_A)^2 + 2(1-r)S_P S_A$$

where: $\overline{P} = \frac{1}{n}\sum_{i=1}^{n} P_i$ $\qquad \overline{A} = \frac{1}{n}\sum_{i=1}^{n} A_i$

$$S_P = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(P_i-\bar{P})^2} \qquad S_A = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(A_i-\bar{A})^2}$$

$$r = [\frac{1}{n}\sum_{i=1}^{n}(P_i-\bar{P})(A_i-\bar{A})]/S_P S_A$$

The first term $(\bar{P}-\bar{A})^2$ will be zero if and only if the average predicted value equals the average sample value. Positive values of the first term will be errors of central tendency or bias. The second term $(S_P-S_A)^2$ will be zero if and only if the standard deviations are equal. Positive values for this term indicate errors of unequal variation. The third term $[2(1-r)S_P S_A]$ is zero if and only if the correlation coefficient between the predicted and actual values (r) is one (that is, if the predicted values always account for variations in the actual values) or if $S_P$ and/or $S_A$ equal zero, a degenerate case.

A more convenient way of expressing this decomposition is to standardize it by dividing all terms by their sum. Thus

$$U_B = \frac{(\bar{P}-\bar{A})^2}{\frac{1}{n}\sum_{i=1}^{n}(P_i-A_i)^2}$$

$$U_M = \frac{(S_P-S_A)^2}{\frac{1}{n}\sum_{i=1}^{n}(P_i-A_i)^2}$$

$$U_R = \frac{2(1-r)S_P S_A}{\frac{1}{n}\sum_{i=1}^{n}(P_i-A_i)^2}$$

$U_B$, $U_M$, and $U_R$ may be characterized as inequality proportions where $U_B$ is the bias proportion; $U_M$ the variance proportion; and $U_R$ the covariance proportion. Obviously $U_B+U_M+U_R=1$.

If the above inequality proportions are to be of value they must provide some insight into the quality of the estimating relationship being evaluated. The term, $U_B$, should be close to zero since least-squares estimation techniques are used to derive coefficient estimates. A high value of $U_M$ indicates that the variance of the independent variable has not been properly accounted for. In such a case a search for other explanatory variables is in order. In other words, the regression equation is not properly specified. A high value of $U_R$ (along with low values of $U_B$ and $U_M$) indicates that the equation is unbiased and properly specified, but the inherent variation in the independent variable cannot be completely explained [Ref. 1].

While the preceding discussion is brief it does point out the problems with testing incremental regression models. Additionally, no single criteria is a reliable test of the postulated models. Therefore, the outcome of all of the test statistics will be used to evaluate the data selected to test the postulated decision rules.

# V. DATA SELECTION AND TESTING

## A. SELECTION

### 1. Appropriation Category

Selection of an appropriate data base centered around acquiring sufficient time-series and cross-sectional data to examine:

a. the effects of aggregation on the suggested decision rules used by the Congress when considering defense appropriations. In particular, data for at least several levels of aggregation (for example, DoD request for Procurement, individual Service requests for Procurement, and Service request for Procurement programs such as aircraft) were considered. This was done in order to forestall criticism similar to Johnson's for the Davis, Dempster, and Wildavsky analyses;

b. possible differences in Congressional behavior towards the different appropriations categories, i.e. does Congress use a different decision rule when considering RDT&E and Procurement; and

c. discernible differences in Congressional behavior when considering requests for programs that represent physical hardware (such as the F-4E tactical fighter aircraft) and those that include requests for non-identifiable weapons systems (for example, RDT&E for Aircraft and Related Equipment).

Congressional changes to the total defense budget for the period Fiscal Years 1950-1975 were studied to determine the magnitude and stability of these changes over time (Figure 3). For this period percentage changes to the Defense budget ranged from +2.0% (1959) to -11.3% (1953) with an average change of -2.5%.

Closer examination of Figure 3 reveals three important results. First, Congressional changes to the Defense budget appear to be fairly stable; Fiscal Year 1953 being the only exception. This result tends to support the concept of incrementalism suggested by Davis, Dempster and Wildavsky -- at least at the highest level of aggregation. Next, the percentage changes between years oscillates in a non-regular cycle between ±5%; again, FY 1953 generating the only exceptions. Finally, those budgets formulated during a Presidential election account for three of the four reductions that exceed 5%[4] (FY 1953 = -11.3%; FY 1969 = -6.8%; FY 1973 = -6.6%). These large reductions may have been the result of election year politics and/or the military may have been in the process of reducing force levels after a major conflict. The latter appears to be the more plausible explanation since the budgets for FY 1961 and FY 1965 were not changed a significant amount while all of the larger

---

[4] The Federal fiscal year is from July 1 to June 30. As such, the FY 1953 budget was submitted to Congress in January 1952. Consideration of this budget took place prior to July 1, 1952.

Figure 3

Congressional Changes to Defense Budget Requests:

FYs 1950-1973

| Fiscal Year | % Change | Change Relative To The Previous Year |
|---|---|---|
| 1950 | - 2.3 | |
| 1951 | - 0.1 | + 2.2 |
| 1952 | - 1.0 | - 0.9 |
| 1953 | -11.3 | -10.3 |
| 1954 | - 3.9 | + 7.4 |
| 1955 | - 3.6 | + 0.3 |
| 1956 | - 1.1 | + 2.5 |
| 1957 | + 1.5 | + 2.6 |
| 1958 | - 1.8 | - 3.3 |
| 1959 | + 2.0 | + 3.8 |
| 1960 | - 0.1 | - 2.1 |
| 1961 | + 1.7 | + 1.8 |
| 1962 | + 0.6 | - 1.1 |
| 1963 | + 0.5 | - 0.1 |
| 1964 | - 3.7 | - 4.2 |
| 1965 | - 1.5 | + 2.2 |
| 1966 | - 0.2 | - 1.3 |
| 1967 | + 0.7 | + 0.9 |
| 1968 | - 2.3 | - 3.0 |
| 1969 | - 6.8 | - 4.5 |
| 1970 | - 7.5 | - 0.7 |
| 1971 | - 3.1 | + 4.4 |
| 1972 | - 4.0 | - 0.9 |
| 1973 | - 6.6 | - 2.6 |

Average Change = -2.5%    Absolute Average Change = 2.8%

Source: Korb [Ref. 27, p. 53]

reductions fall at or near the end of a major conflict (1953 - Korea; 1969, 1970, and 1973 - Vietnam).

To determine the distribution of changes within the Defense budget Congressional changes to the appropriation categories of Military Personnel, Procurement, Operations and Maintenance, and RDT&E were investigated. One major difficulty with this type analysis was accounting for numerous differences in the aggregation of program elements under these categories (notably, Procurement and RDT&E) between the periods FYs 1950-1959 and FYs 1960-1973. Stromberg [Ref. 36] includes data for the period FYs 1953-1959 but also acknowledges the problem of assigning specific program elements to individual appropriation categories. Therefore, only the latter period (FYs 1960-1973) for which published OSD figures are available was considered. For this period changes to the four categories ranged from +9.48% (RDT&E - FY 1962) to -15.9% (Procurement - FY 1973). A complete summary of Congressional changes to Military Personnel, Procurement, Operations and Maintenance, and RDT&E is includes as Figure 4.

Information provided by Figure 4 indicates that:

(1) concentrating on the total defense budget tends to obscure the much larger changes in the individual appropriation categories;

(2) the majority of the larger changes were concentrated in those categories that contain funds for development and production of new weapons systems (RDT&E and Procurement); and

Figure 4

Congressional Changes (%) to the Defense Budget According to Appropriation Categories; FYs 1960-1973

| Category | 1960 | 1961 | 1962 | 1963 | 1964 |
|---|---|---|---|---|---|
| Military Personnel | +0.11 | +0.18 | -0.46 | -1.12 | -2.90 |
| Operations & Maint. | -0.65 | -0.59 | -0.53 | -0.03 | -0.66 |
| Procurement | -0.09 | +3.32 | -1.10 | +1.23 | -6.09 |
| RDT&E | +1.19 | +6.85 | +9.48 | +2.62 | -4.31 |
| Total Defense Budget | -0.06 | +1.68 | +0.58 | +0.48 | -3.66 |

| | 1965 | 1966 | 1967 | 1968 | 1969 |
|---|---|---|---|---|---|
| Military Personnel | -0.10 | +0.27 | +0.29 | -1.00 | -1.92 |
| Operations & Maint. | -0.67 | +0.17 | +0.18 | -1.46 | -4.49 |
| Procurement | -2.43 | -0.07 | +1.43 | -4.00 | -14.07 |
| RDT&E | -4.06 | -2.07 | +1.14 | -2.25 | -5.68 |
| Total Defense Budget | -1.51 | -0.18 | +0.70 | -2.30 | -6.75 |

| | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|
| Military Personnel | -3.31 | -1.23 | -1.06 | -1.88 |
| Operations & Maint. | -4.28 | -0.78 | -1.68 | -2.42 |
| Procurement | -14.58 | -7.65 | -9.67 | -15.91 |
| RDT&E | -10.37 | -4.99 | -5.41 | -9.22 |
| Total Defense Budget | -7.49 | -3.13 | -4.02 | -6.56 |

| | Average Change | Absolute Average Change |
|---|---|---|
| Military Personnel | -1.07 | 1.13 |
| Operations & Maintenance | -1.30 | 1.32 |
| Procurement | -5.40 | 5.82 |
| RDT&E | -3.45 | 4.97 |

Source: Korb [Ref. 27, p. 55]

(3) the reduction in defense spending which has accompanied termination of active participation in Vietnam combat operations has been borne primarily by Procurement and RDT&E rather than being equally distributed among all appropriation categories.

This last point has been used by both Kanter [Ref. 26] and Korb [Ref. 17] to draw basically divergent conclusions concerning the nature of Congressional interest in the Defense budget. Kanter claims that concentration of changes in Procurement and RDT&E implies that Congress maintains a programmatic orientation (making decisions on the basis of the type of weapons systems procured by the Defense Department) toward defense spending [Ref. 26, p. 130]. Korb argues that, although large reductions have been made in Procurement and RDT&E funding requests, few weapons systems have been cancelled outright; that Congress may delay or stretch out a program but that funds are invariably allocated. Hence, Congressional orientation toward defense spending is more fiscal (primarily concerned with the level of spending) than programmatic [Ref. 29, p. 59]. While this discussion is not necessarily germane to the subject of data selection it does point out the different possible interpretations of available statistics on defense appropriations.

Comparison of the OSD data on changes to appropriation categories for FYs 1960-1973 with the results of Stromberg's analysis for FYs 1953-1968 disclosed that there has been little change in the distirbution of Congressional cuts

to the defense budget over the years. This fact plus the criteria suggested by Fenno[5] indicated that confining this study to Procurement and RDT&E would reduce the amount of the analysis but not impact on the significance of the results.

Selection of Procurement and RDT&E for study has an additional benefit in that RDT&E represents funding for conceptual weapons systems while Procurement includes funding for programs that are directly related to identifiable military hardware. Comparison of the relative fitting capability of the decision models between RDT&E and Procurement should provide some insight into differences in Congressional behavior when considering identifiable and non-identifiable weapon systems.

2. Data Sources

In order to empirically test the decision models presented in Chapter III a data base that included the previous and current year's request and appropriation was needed. Data sources available included:

a. spread sheets used by the Senate Committee on Armed Services (printed by the Committee)[Ref. 12];

b. summary tables prepared by the Services in Hearings before Senate and House Subcommittees on Appropriations [Ref. 13];

---

[5] As one standard of comparison, Fenno considered changes of less than five percent to be insignificant in his survey of nonmilitary appropriations for 1947 to 1962 [Ref. 20, p. 353].

c. summary tables of the United States Budget for Fiscal Years 1953-1973 [Ref. 38] and

d. tabulated data summaries included in Stromberg's analysis of the Defense budget process, FYs 1953-1968 [Ref. 36].

Utilizing the information available in these documents sufficient data to test the hypothesized decision models were compiled for all levels of aggregation. However, there were some unexplained inconsistencies between sources. For example, Stromberg's totals for PEMA (Procurement of Equipment and Missiles - Army), PAMN (Procurement of Aircraft and Missiles - Navy), and Procurement of Aircraft and Missiles - Air Force were consistent with summaries provided in source c but totals for DoD Procurement could not be reconciled with the same document. This necessarily restricted analysis of Procurement - Department of Defense to data provided in Senate spread sheets (source a). Also, lack of spread sheets for FY 1972 confined study of the program and program element levels of aggregation to FY 1970 and 1971 (see section V-B for definition of these levels of aggregation). While these discrepancies posed certain analytical constraints the remaining data does represent an accurate summary of requests and Congressional appropriations.

## B. TESTING

Study of the proposed decision models involved analysis of the following levels of aggregation for Procurement and RDT&E:[6]

Level 1. Department of Defense - the aggregate sum of requests and appropriations for all agencies within the Defense Department, i.e., Army, Navy (includes Marine Corps), Air Force, and Defense Agencies.

Level 2. Service - aggregate sums of requests and appropriations for programs that make up Army, Navy (plus Marine Corps) and Air Force RDT&E and Procurement.

Level 3. Program[7] - aggregate sums of requests and appropriations for program elements of a program within Procurement and RDT&E for the individual services (an example would be PEMA - Procurement of Equipment and Missiles, Army).

Level 4. Program Element[8] - amounts requested and appropriated for the individual weapon systems and related activities that make up the Defense budget[9].

Prior to regression analysis, plots were made of appropriations vs requests in order to pictorially view the validity of assuming linear models and further, to gain a general idea of the impact of suppressing the constant term in the models. These plots (see Figures 10 through 15 for RDT&E

---

[6] See Figure 5 for an example of the different levels of aggregation.

[7] See Figures 6 and 7 for a listing of the programs investigated in this thesis.

[8] Figures 8 and 9 list those program elements studied.

[9] Program elements for Procurement of aircraft and related equipment were broken into two categories - Quantity Items (QI) where quantities to be purchased were included with the request and Non-Quantity Items (NQI) for which no specific weapon system or quantity could be identified with the requests - to investigate possible differences in behavior for these categories.

Figure 5

Levels of Aggregation For Procurement

| Program | Service | | | | | | |
|---|---|---|---|---|---|---|---|
| | Army | | Navy and Marine Corps | | Air Force | | |
| | Program Element | Request | Program Element | Request | Program Element | Request | |
| 1. Aircraft | CH-47 | XXXX | A-4M | XXXX | A-70 | XXXX | (LEVEL 4) |
| | AH-1 | XXXX | A-6E | XXXX | F-4E | XXXX | |
| | OH-58 | XXXX | F-14A | XXXX | F-15A | XXXX | |
| | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | |
| | Total Aircraft - Army | | Total Aircraft - Navy | | Total Aircraft - Air Force | | (LEVEL 3) |
| | Program Element | Request | Program Element | Request | Program Element | Request | |
| 2. Missiles | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | |
| | Total Missiles - Army | | Total Missiles - Navy | | Total Missiles - Air Force | | |
| 3. Tracked Combat Vehicles | | | | | | | |
| 4. ---------- | | | | | | | |
| 5. ---------- | | | | | | | |

Total Procurement - Services: Army = sum of program requirements
Navy = sum of program requirements (LEVEL 2)
Air Force = sum of program requirements

Total DoD Procurement = sum of Army, Navy-Marine Corps, Air Force and Defense Agencies needs (LEVEL 1)

Figure 6

RDT&E Programs Studied

A. ARMY

1. Military Sciences
2. Aircraft and Related Equipment
3. Missiles and Related Equipment
4. Military Astronautics
5. Ordnance, Combat Vehicles, and Related Equipment
6. Other Equipment
7. Programwide Management and Support

B. NAVY

1. Military Sciences
2. Aircraft and Related Equipment
3. Missiles and Related Equipment
4. Military Astronautics
5. Ships and Small Craft Related Equipment
6. Ordnance, Combat Vehicles, and Related Equipment
7. Other Equipment
8. Programwide Management and Support

C. AIR FORCE

1. Military Sciences
2. Aircraft and Related Equipment
3. Missiles and Related Equipment
4. Military Astronautics
5. Ordnance, Combat Vehicles, and Related Equipment
6. Other Equipment
7. Programwide Management and Support

Figure 7

Procurement Programs Studied

AIRCRAFT:
- Army
- Navy and Marine Corps
- Air Force

MISSILES:
- Army
- Navy
- Marine Corps
- Air Force

TRACKED COMBAT VEHICLES:
- Army
- Marine Corps

NEW SHIP CONSTRUCTION
- Navy

OTHER WEAPONS
- Army
- Navy
- Marine Corps

Figure 8

RDT&E Program Elements Included in Analysis

| Service | Program Element Number | Program Element Title |
|---|---|---|
| Army | 231619A | Main Battle Tank |
| | 23625A | Adv. Aerial Fire Support System |
| | 28012A | Defense Communications Planning Group |
| | 33111A | Strategic Army Communications |
| | 61101A & 61102A | Defense Research Sciences |
| | 63302A | Surface to Air Missile Development |
| | 63304A | Adv. Ballistic Missile Defense |
| | 63767A | Project Mallard |
| | 64206A | Utility Tactical Transport Aircraft System |
| | 64303A | Missile Effectiveness Evaluation |
| | 64501A | Sea to Inland Logistics System |
| | 64601A | Infantry Support Weapons |
| Navy | 11221N | Fleet Ballistic Missile System |
| | 11314N | FBM Command Control |
| | 24122N | F-14 Squadrons |
| | 25603N | Condor |
| | 61102N | Defense Research Sciences |
| | 63314N | Undersea Long-Range Missile System |
| | 64202N | S-3 Aircraft Development |
| | 64214N | Crane Helicopter Lift |
| | 64303N | Adv. Surface Missile System |
| Air Force | 12410F | Airborne Warning and Control System |
| | 27214F | RF-111 Squadrons |
| | 34111F | Special Activities |
| | 35110F | Satellite Control Facility |
| | 35121F | MOL |
| | 41214F | Air Cargo Materials Handling |
| | 61101F | In-House Laboratory Independent Research |
| | 61102F | Defense Research Sciences |
| | 62101F | Environment |
| | 62102F | Materials |
| | 62203F | Aerospace Propulsion |
| | 62204F | Aerospace Avionics |
| | 62302F | Rocket Propulsion |
| | 63202F | Aircraft Propulsion Subsystem Integration |
| | 63204F | Light Intratheater Transport |
| | 63214F | VTOL Engine Development |
| | 63225F | Subsonic Cruise Armed Decoy |
| | 63229F | Conus Air Defense Interceptor |
| | 63311F | Adv. Ballistic Reentry System |
| | 63723F | Civil Engineering Technology |
| | 64211F | A-X Aircraft |
| | 64307F | Hard Rock Silo Development |

Figure 8 (Cont.)

| Service | Program Element Number | Program Element Title |
|---|---|---|
| | 64308F | Short Range Air-to-Air Missile |
| | 64723F | Adv. Airborne Command Post |
| | 65101F | Rand |
| | 65102F | Anser |
| | 65301F | Western Test Range |
| | 65302F | Eastern Test Range |
| | 65705F | Lincoln Laboratory |
| | 65706F | Mitre |
| | 65806F | Space and Missile System Organization |

Figure 9

Procurement Program Elements Included in Analysis

A. AIRCRAFT

| Service | Program Element Title | Type[a] | Code[b] |
|---|---|---|---|
| Army | CH-47 Cargo Transport Helicopter | QI | 0101 |
| | UH-1 Utility Transport Helicopter | QI | 0102 |
| | AH-1 Armed Helicopter | QI | 0103 |
| | OH-6/58 Observation Helicopter | QI | 0104 |
| | Items Less than $500,000 | NQI | 0105 |
| | Modification of Aircraft | NQI | 0106 |
| | Common Ground Equipment | NQI | 0107 |
| | Component Improvement | NQI | 0108 |
| | Other Production Charges | NQI | 0109 |
| | Ground Support Avionics | NQI | 0110 |
| | Aircraft Spares and Repair Parts | NQI | 0111 |
| Navy and Marine Corps | A-4M Light Attack Skyhawk | QI | 0201 |
| | A-6A/E All Weather Attack Intruder | QI | 0202 |
| | A-6A/E Adv. Procurement, Current Year | NQI | 0203 |
| | EA-6B Electronic Warfare Intruder | QI | 0204 |
| | EA-6B Adv. Procurement, Current Year | NQI | 0205 |
| | AV-8A VSTOL Harrier | QI | 0206 |
| | AV-8A Adv. Procurement, Current Year | NQI | 0207 |
| | A-7E Medium Attack Corsair II | QI | 0208 |
| | F-14A Fighter, Interceptor | QI | 0209 |
| | F-14A Adv. Procurement, Current Year | NQI | 0210 |
| | UH-1N Utility Helicopter Iroquois | QI | 0211 |
| | UH-1N Adv. Procurement, Current Year | NQI | 0212 |
| | P-3C ASW Aircraft, Orion | QI | 0213 |
| | P-3C Adv. Procurement, Current Year | NQI | 0214 |
| | S-3A ASW Aircraft, Carrier Based | QI | 0215 |
| | S-3A Adv. Procurement, Current Year | NQI | 0216 |
| | E-2C Early Warning Aircraft | QI | 0217 |
| | E-2C Adv. Procurement, Current Year | NQI | 0218 |
| | T-2C Trainer Aircraft | QI | 0219 |
| | TA-4J Trainer Aircraft | QI | 0220 |
| | TA-4J Adv. Procurement, Current Year | NQI | 0221 |
| | Modification of Aircraft | NQI | 0222 |
| | Aircraft Spare and Repair Parts | NQI | 0223 |
| | Aircraft Component Improvement | NQI | 0224 |
| | Aircraft Industrial Facilities | NQI | 0225 |
| | Other Aircraft Production Charges | NQI | 0226 |
| | Common Ground Equipment | NQI | 0227 |

[a] Designation assigned to Program Element; QI (Quantity Item), NQI (Non-Quantity Item)

[b] Author's code with which the reader may determine requests and appropriations found in Appendix C.

Figure 9 (Cont.)

| Service | Program Element Title | Type | Code |
|---|---|---|---|
| Air Force | A-7D Tactical Attack Fighter | QI | 0301 |
| | A-7D Adv. Procurement, Current Year | NQI | 0302 |
| | F-4E Tactical Fighter | QI | 0303 |
| | F-4E Adv. Procurement, Current Year | NQI | 0304 |
| | F/RF-5A/B Tactical Fighter | QI | 0305 |
| | F-111D Adv. Tactical Fighter | QI | 0306 |
| | F111D/F Fiscal Year 1969 and Prior Over Target | NQI | 0307 |
| | RF-4C Tactical Reconnaissance Fighter | QI | 0308 |
| | RF-4C Adv. Procurement, Current Year | NQI | 0309 |
| | C-5A Prior Year Unfunded Deficiencies and Contingency Provisions | NQI | 0310 |
| | C-9A Transport | QI | 0311 |
| | T-37C Primary Trainer | QI | 0312 |
| | T-41C Basic Trainer | QI | 0313 |
| | T-X Navigational Trainer | QI | 0314 |
| | UH-1N Utility Helicopter | QI | 0315 |
| | U-17B Utility Aircraft | QI | 0316 |
| | Modification of Aircraft | NQI | 0317 |
| | Aircraft Spares and Repair Parts | NQI | 0318 |
| | Common Ground Equipment | NQI | 0319 |
| | Component Improvement | NQI | 0320 |
| | Industrial Facilities | NQI | 0321 |
| | War Consumables | NQI | 0322 |
| | Other Production Charges | NQI | 0323 |
| | Miscellaneous | NQI | 0324 |

and Figures 16 through 23 for Procurement at the end of this chapter) reveal that the assumption of linearity and elimination of the constant term appear to be reasonable.

Close scrutiny of Figures 10 through 23 reveals two points. First, comparing Figures 10 through 15 and 16 through 23 in sequential order (comparison on a descending level of aggregation within categories) indicates that the data dispersion pattern appears to be more pronounced as the level of aggregation is reduced; Procurement exhibiting this trend more than RDT&E. Next, comparing RDT&E and Procurement plots (see Figures 10 and 16; 11, 12, 13, and 17, 18, 19, 20; 14 and 21; 15 and 22, 23 at the end of this chapter) reveals that data dispersion is more pronounced for Procurement than RDT&E at similar levels of aggregation. One possible explanation for this noted difference may be the types of requests represented by Procurement (physical hardware) and RDT&E (conceptual weapons systems).

Graphical analysis of the data via appropriation vs request plots does not allow for identification of point departures from a trend or changes in a trend over a period of years. For this reason the time-series data for DoD and Service levels of aggregation (levels 1 and 2) were plotted according to the percentage of request appropriated (appropriation/request) vs time. These plots are included as Figures 24 through 32.

Viewing the data in this manner indicates that the percentage of request appropriated[10] was more stable for the period FYs 1963-1973 than for FYs 1953-1962. These figures also point out the more favorable funding increments realized in the earlier period. Sapolsky [Ref. 34, p. 160-173] attributes these higher funding increments to the numerous strategic programs initiated in the 1950's.

The final step in the testing process consisted of applying the Mann-Whitney test to the time-series data for DoD and the Services in an effort to determine homogeneity within the samples. Based on military policy differences between Eisenhower's "massive retaliation", Kennedy and Johnson's "flexible response", and Nixon's "balance of power" doctrines the data were divided into three subgroups; FYs 1953-1959, FYs 1960-1969, and FYs 1970-1973.[11] The following is a

---

[10] Percent of request appropriated is somewhat misleading unless the amount requested is also considered. For example, in FY 1955 the Navy requested 61.0 million dollars for RDT&E. Congress responded by appropriating 419.88 million dollars or 688% of request. In FY 1956 the Navy reacting to an obviously favorable funding climate, requested and received 439.2 million dollars for RDT&E.

[11] Other dates of interest tested were FY 1961 - to investigate the impact of the newly formed Congressional Authorization Committees; and FY 1963 - to determine if the introduction of PPBS into the defense resource planning process had significant impact on the stream of appropriations. No statistical differences in the data were noted for these dates. Possible explanations for this result may be that the more controversial requests were not included in the main budget submission but were included in supplemental requests and thereby bypassed the normal authorization process or that they were "buried" in aggregate requests until the project had gained sufficient momentum and was difficult to cancel (the Cheyenne helicopter is a good example of the latter). Also, PPBS is a DoD resource planning guide and, as such, may not have much influence on the Congress.

summary of the results obtained and represents final grouping of the data upon which linear regression analyses were made. Numerical results for the Mann-Whitney tests are included as Appendix A.

1. RDT&E

a. Department of Defense

FYs 1953-1959 not statistically different from FYs 1960-1969; FYs 1970-1973 statistically different from FYs 1953-1969.

final grouping - FYs 1953-1969 and FYs 1970-1973.

b. Services

(1) Army. same as DoD.

final grouping - FYs 1953-1969 and FYs 1970-1973.

(2) Navy. FYs 1953-1969 not statistically different from FYs 1970-1973.

final grouping - FYs 1953-1973.

(3) Air Force. same as DoD.

final grouping - FYs 1953-1969 and FYs 1970-1973.

(4) Services Pooled (FYs 1970-1973).[12] the hypothesis of a single population could not be rejected. Army, Navy, and Air Force RDT&E may be combined into a single sample.

---

[12] Fiscal Years 1970-1973 for all services were combined and tested to determine if they represented a single, homogeneous sample.

2. Procurement

a. Department of Defense[13]

FYs 1964-1969 not statistically different from FYs 1970-1973.

final grouping - FYs 1964-1973.

b. Services

(1) Procurement Equipment and Missiles - Army. FYs 1953-1969 statistically different from FYs 1970-1973.

final grouping - FYs 1953-1969 and FYs 1970-1973.

(2) Procurement Aircraft and Missiles - Navy. FYs 1953-1969, FYs 1960-1969, and FYs 1970-1973 statistically different.

final grouping - FYs 1953-1959, FYs 1960-1969, and FYs 1970-1973.

(3) Procurement Missiles - Air Force. FYs 1953-1969 statistically different from FYs 1970-1973.

final grouping - FYs 1953-1969 and FYs 1970-1973.

(4) Procurement Aircraft - Air Force. FYs 1953-1969 statistically different from FYs 1970-1973.

final grouping - FYs 1953-1969 and FYs 1970-1973.

(5) Services Pooled - FYs 1970-1973. the hypothesis of a single population could not be rejected. Procurement Equipment and Missiles - Army, Procurement Aircraft

---

[13] Data for FYs 1953-1963 were not available for DoD procurement. Test results may have been different had this information been accessible.

and Missiles - Navy, Procurement Missiles - Air Force, and Procurement Aircraft - Air Force may be combined into a single sample.

This grouping of the data allowed for testing the postulated decision models at the four levels of aggregation previously defined for RDT&E and Procurement. Chapter VI outlines the methods used and significant results are evaluated in light of specific hypotheses proposed for the Congressional-DoD budgetary process.

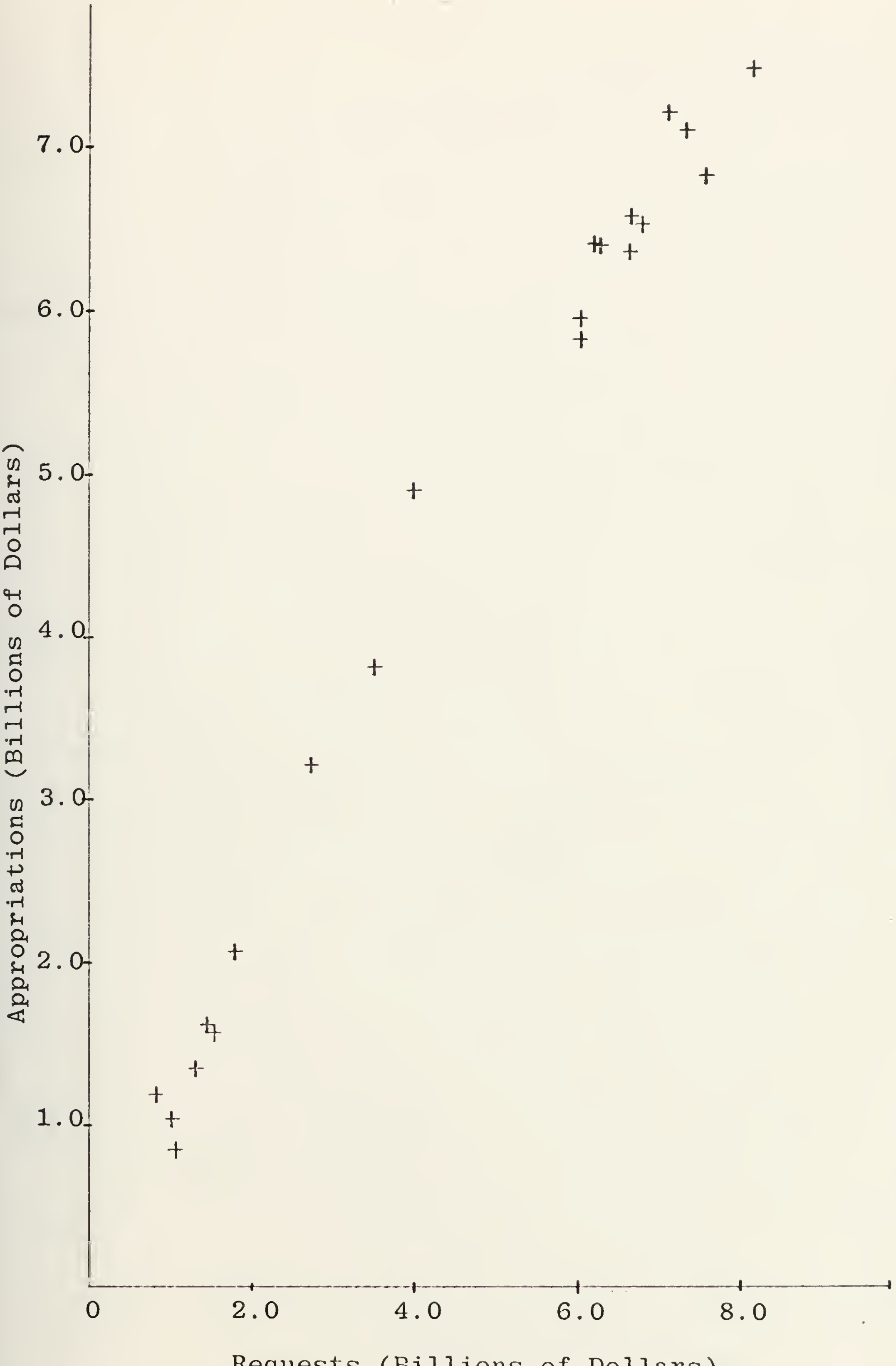



Figure 10. Appropriations vs Requests - DoD RDT&E: FYs 1953-1973

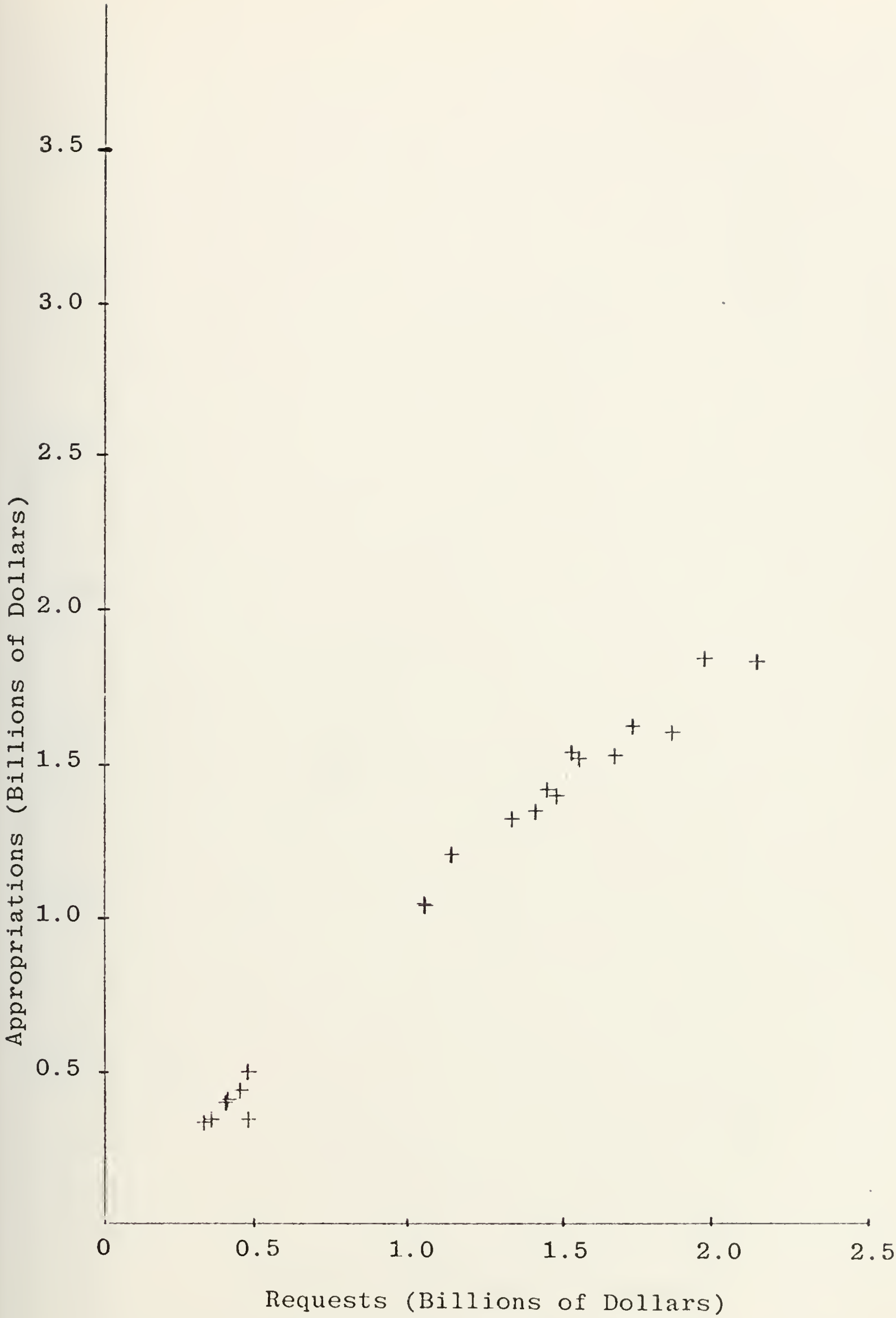



Figure 11. Appropriations vs Requests - Army RDT&E: FYs 1953-1973

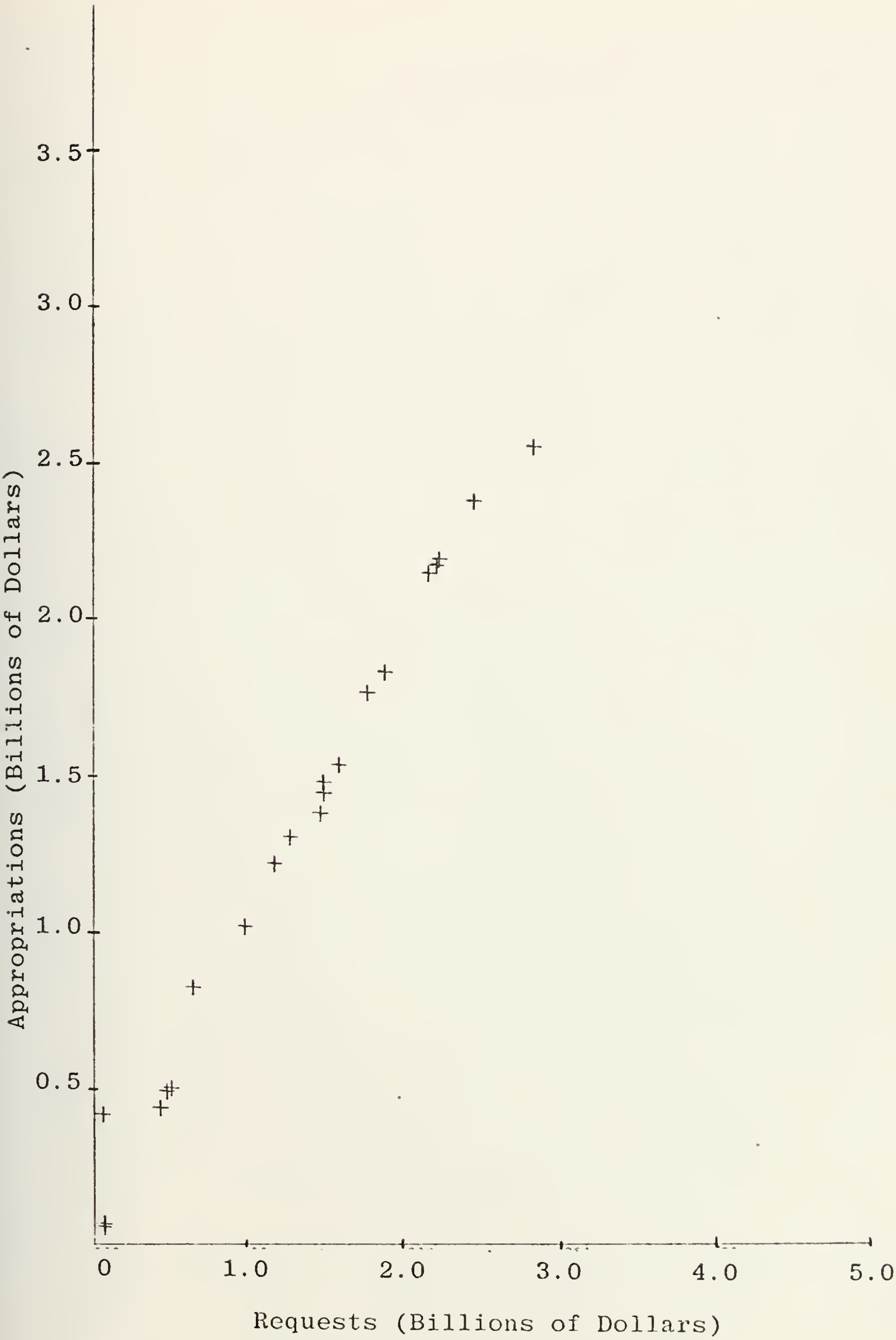



Figure 12. Appropriations vs Requests - Navy RDT&E: FYs 1953-1973

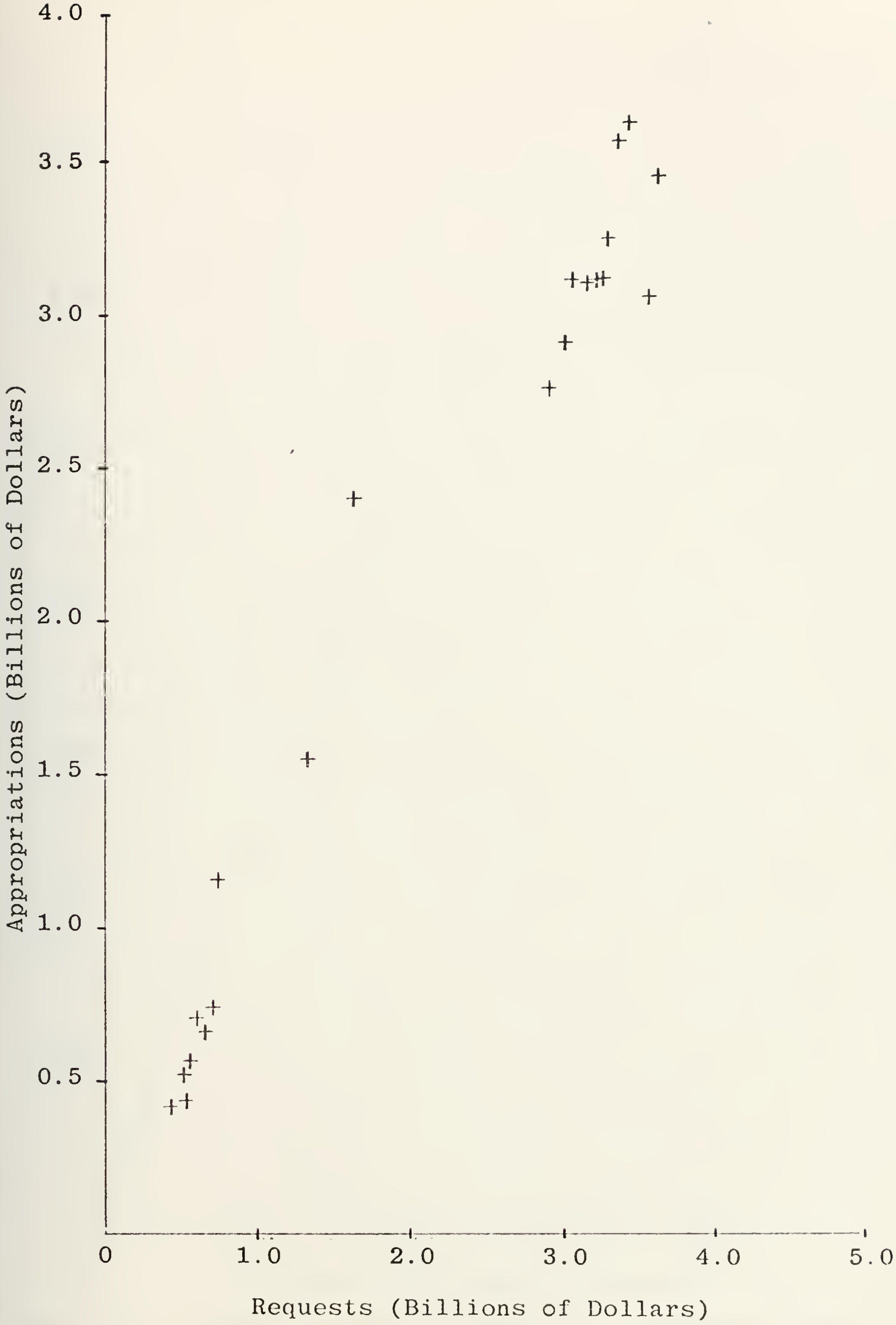



Figure 13. Appropriations vs Requests - Air Force RDT&E: FYs 1953-1973

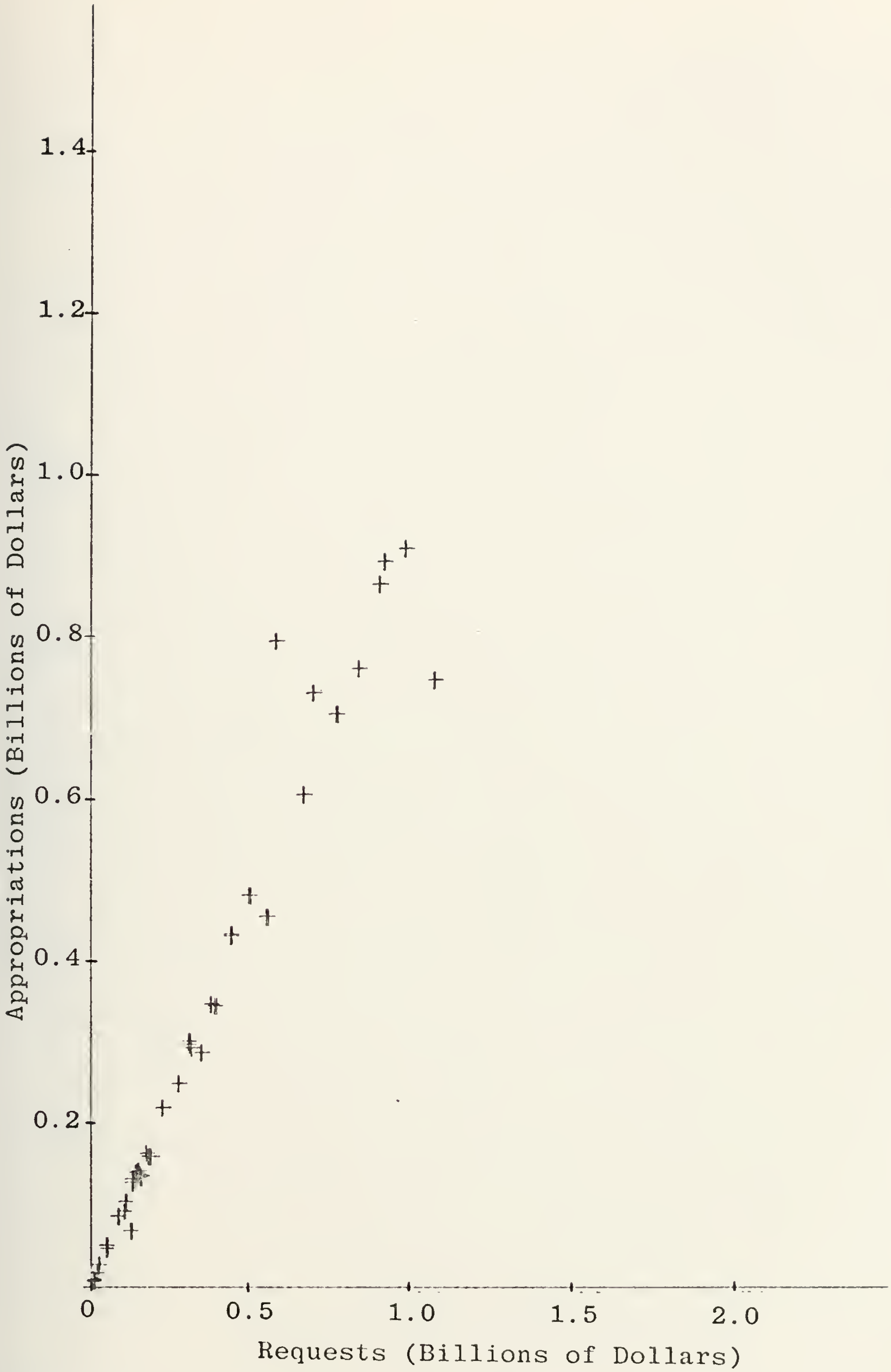



Figure 14. Appropriations vs Requests - RDT&E Programs: FYs 1970 and 1971

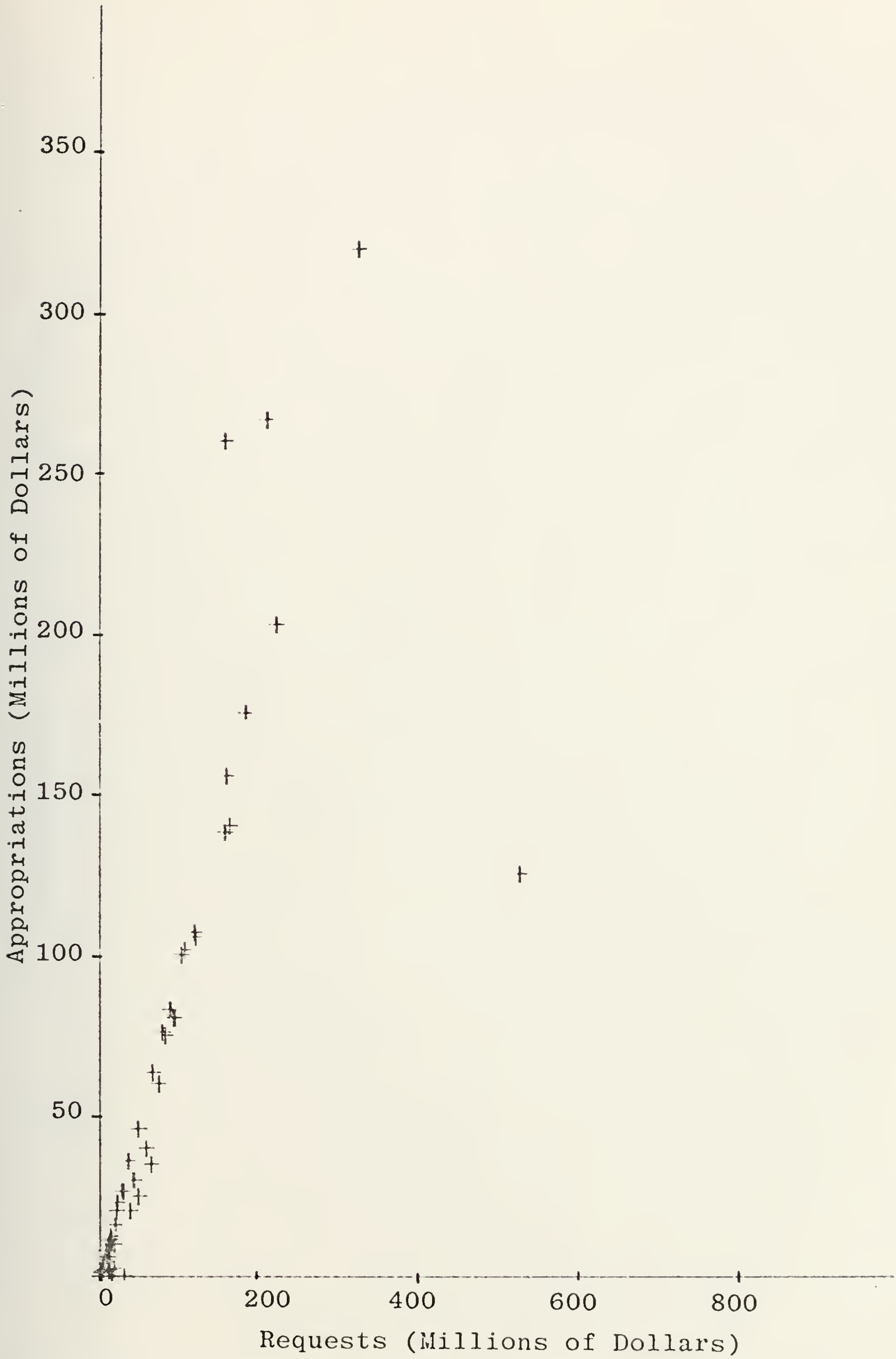



Figure 15. Appropriations vs Requests - RDT&E Program Elements: FYs 1970 and 1971

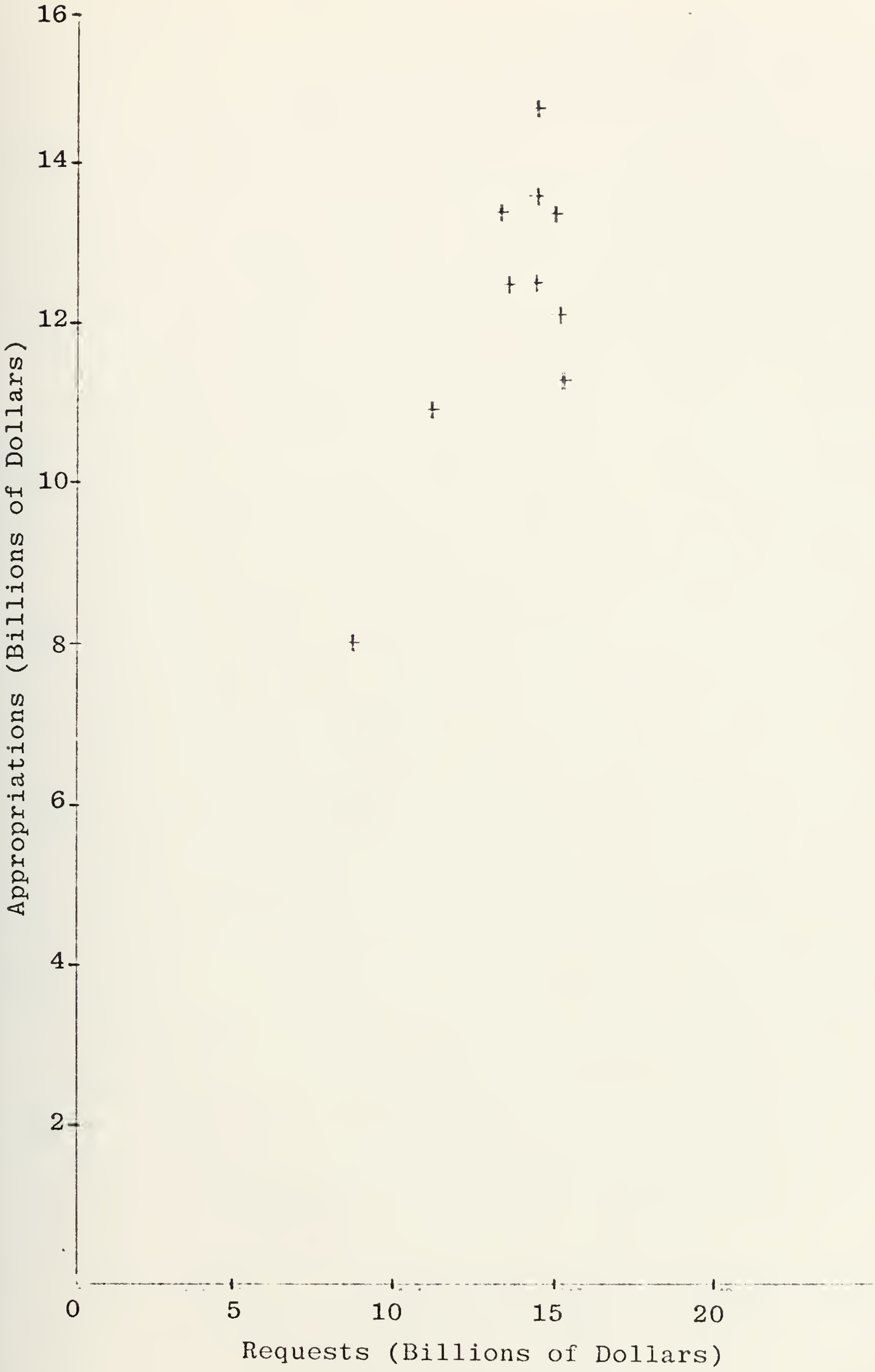



Figure 16. Appropriations vs Requests - DoD Procurement: FYs 1964-1973

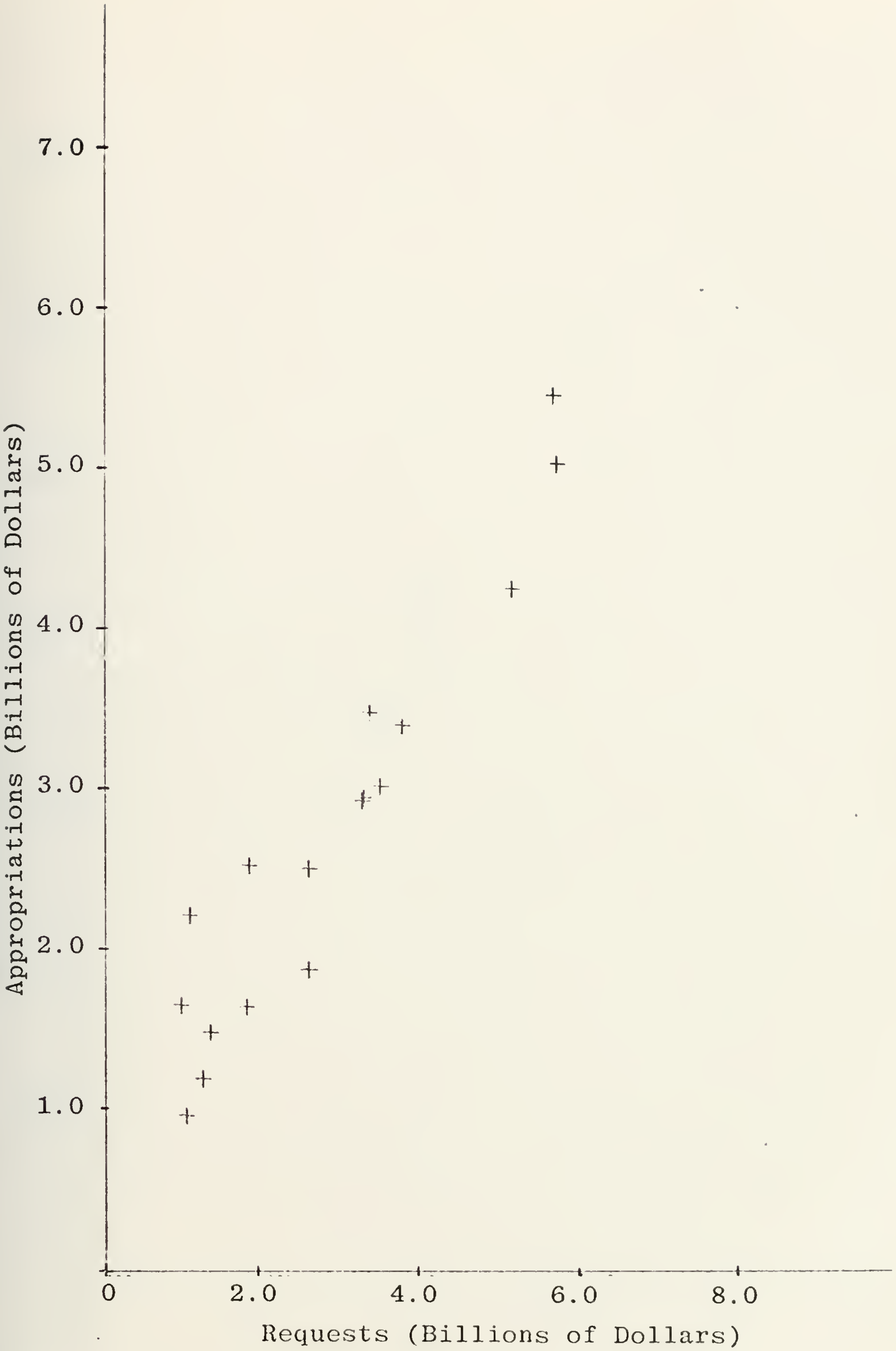



Figure 17. Appropriations vs Requests - Army Procurement Equipment and Missiles: FYs 1953-1973

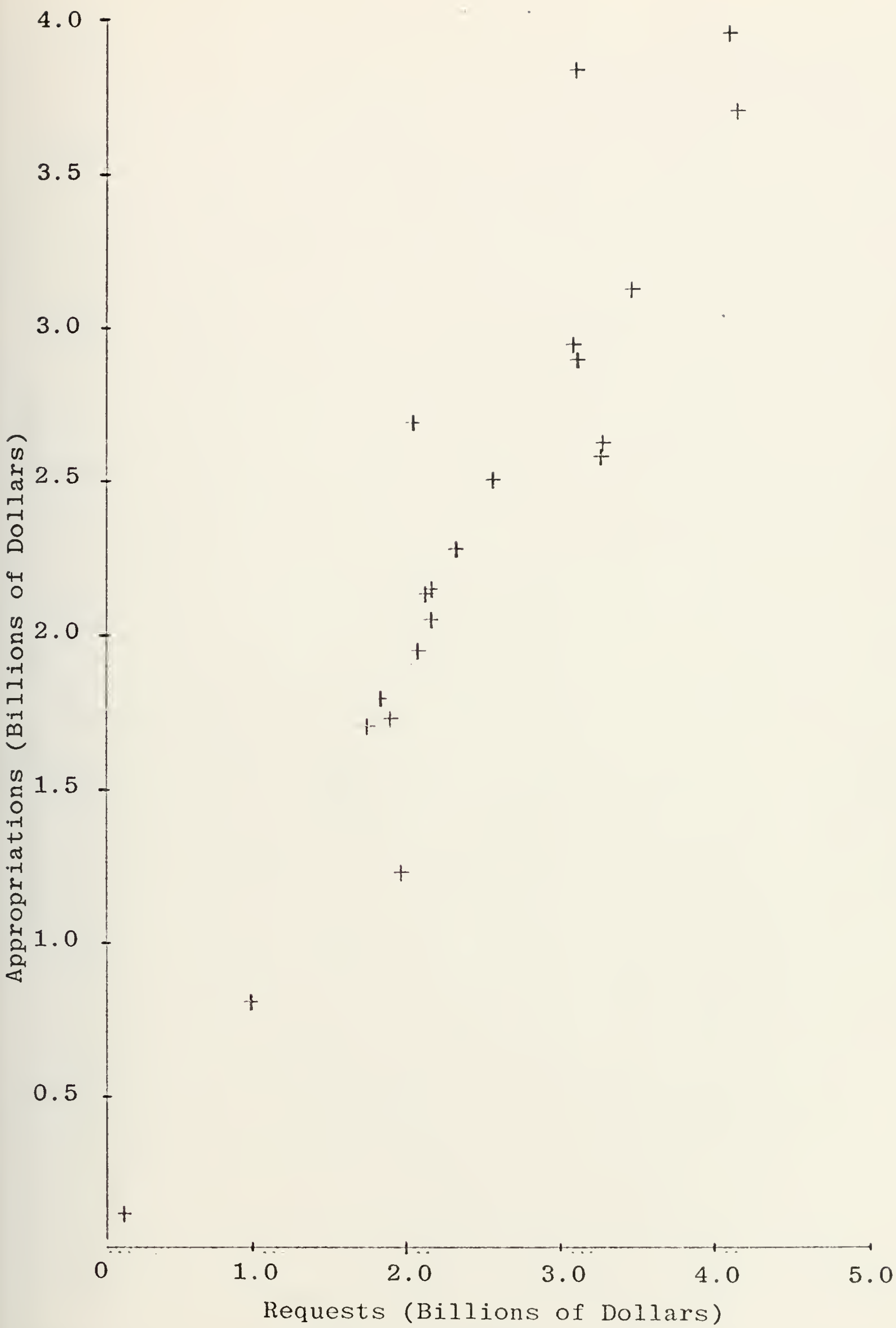



Figure 18. Appropriations vs Requests - Navy Procurement Aircraft and Missiles: FYs 1953-1973

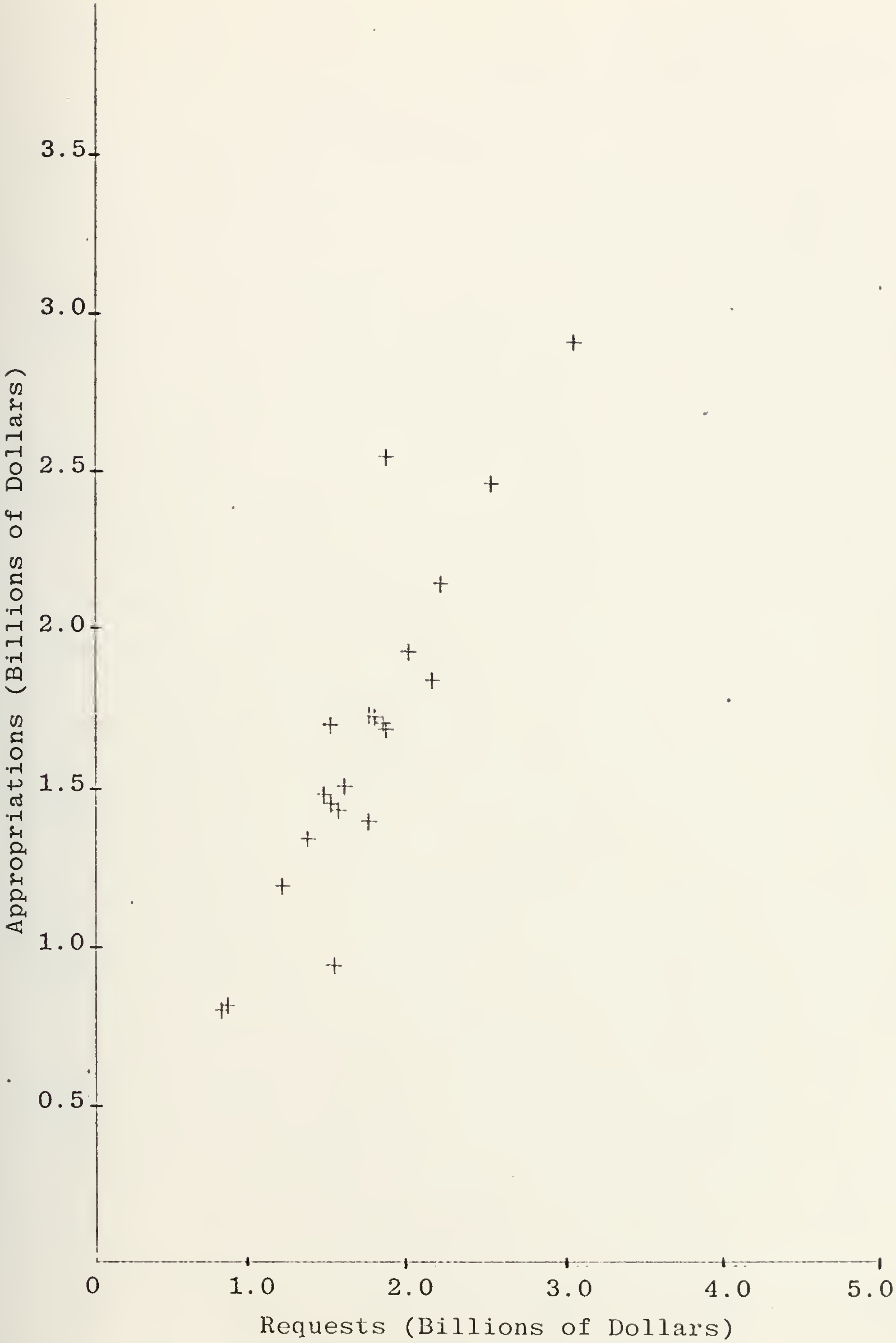



Figure 19. Appropriations vs Requests - Air Force Procurement, Missiles: FYs 1953-1973

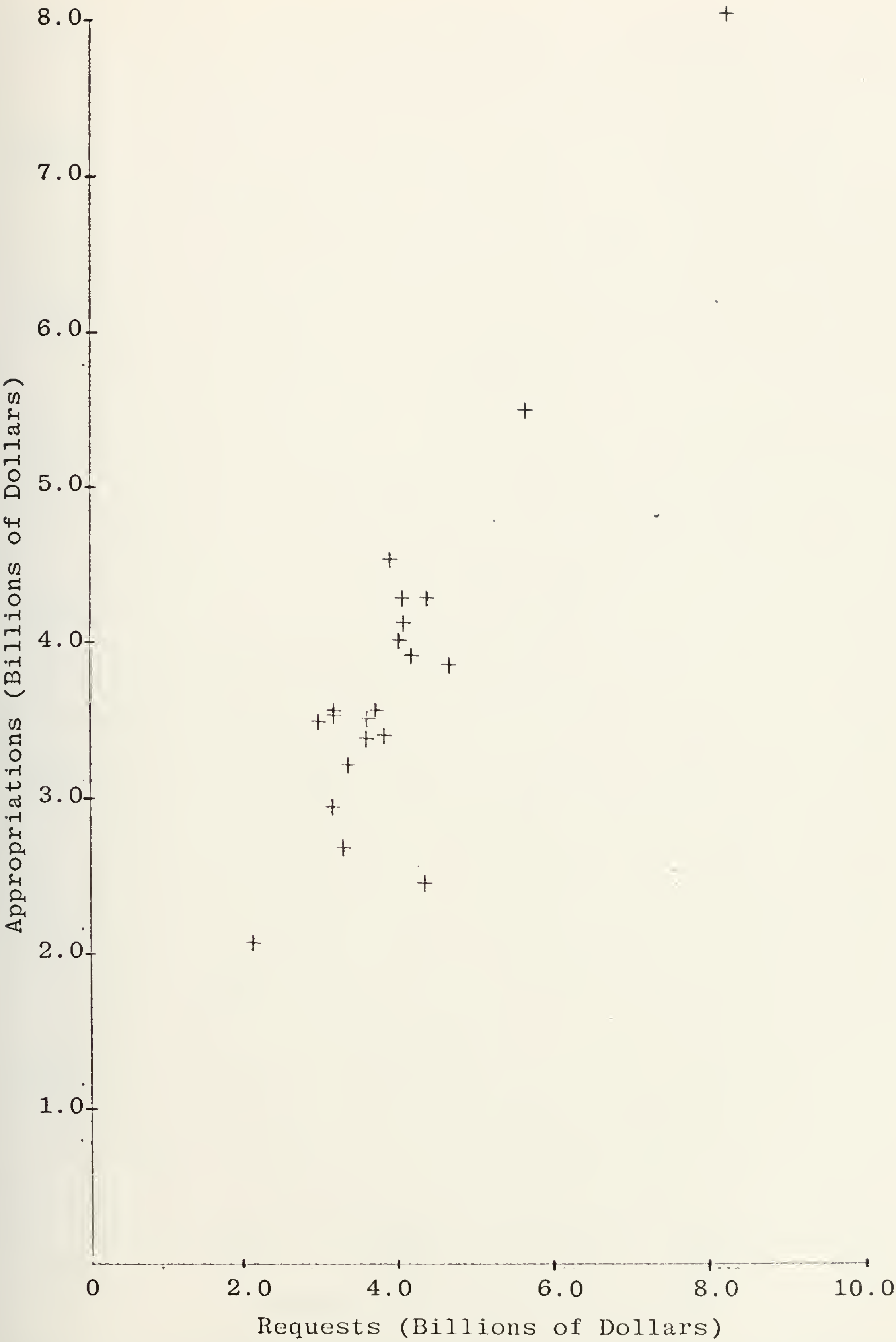



Figure 20. Appropriations vs Requests - Air Force Procurement, Aircraft: FYs 1953-1973

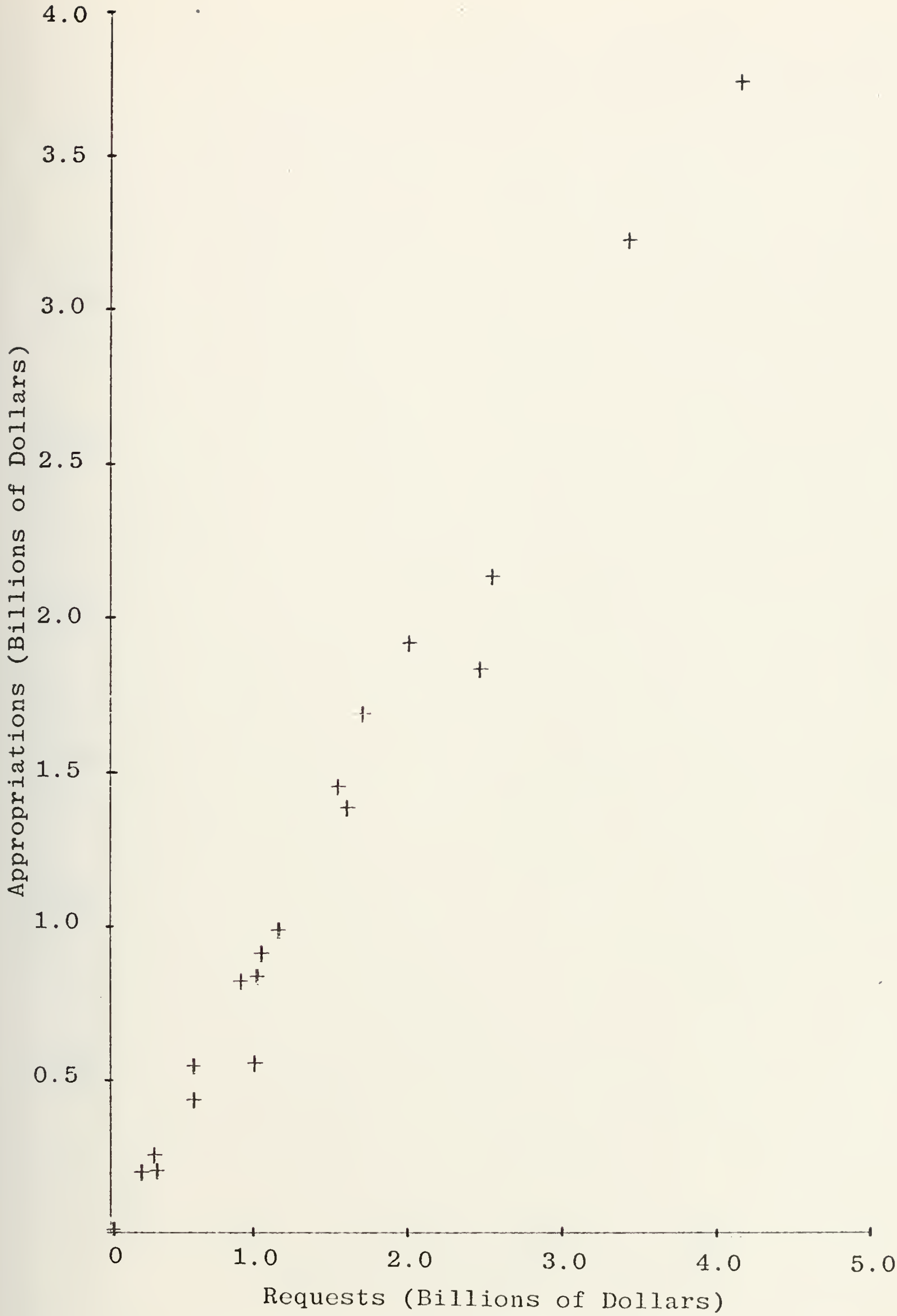



Figure 21. Appropriations vs Requests - Programs, Procurement: FYs 1970 and 1971

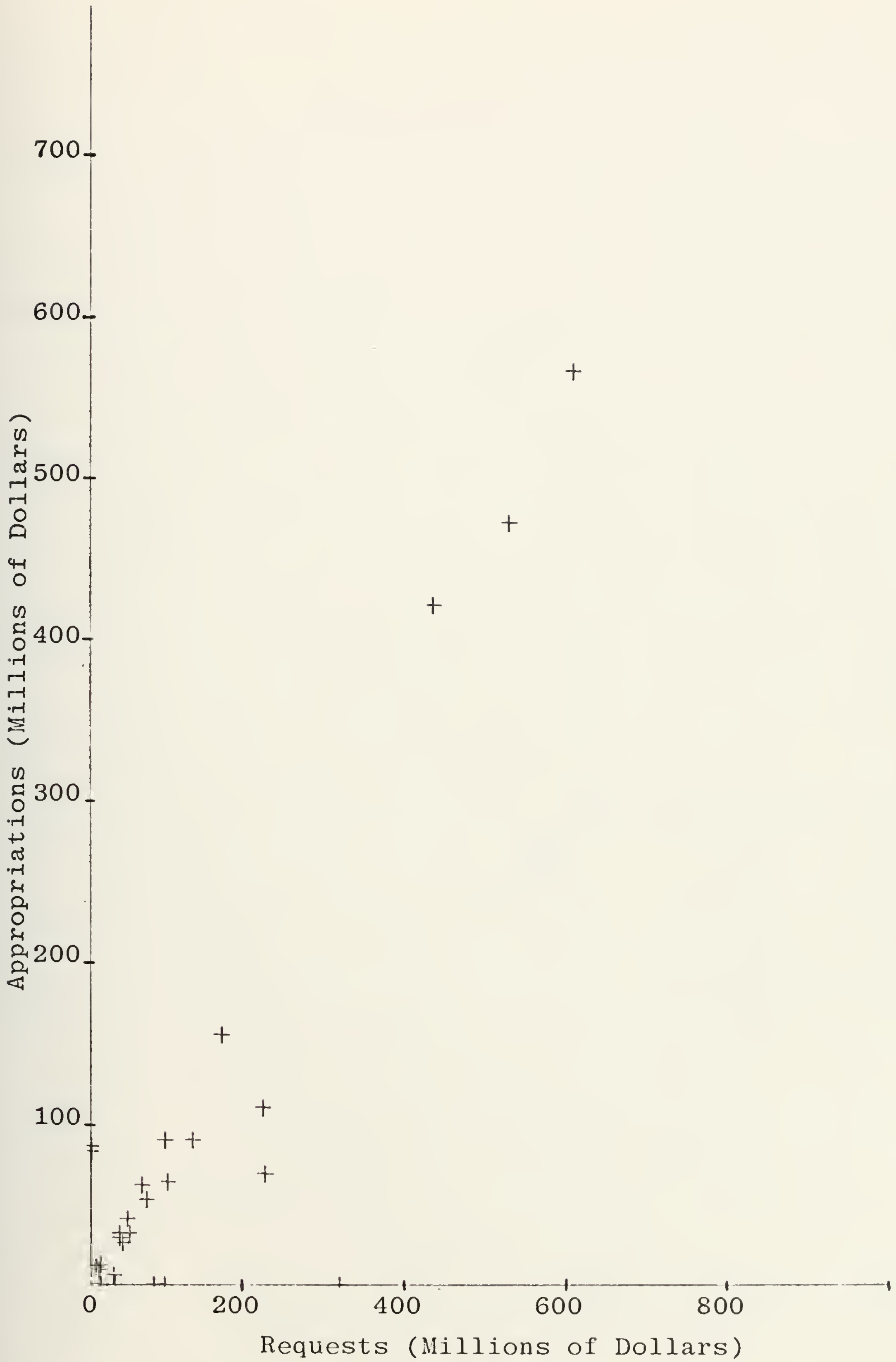



Figure 22. Appropriations vs Requests - Quantity Items, Program Element Level, Procurement: FYs 1970 and 1971

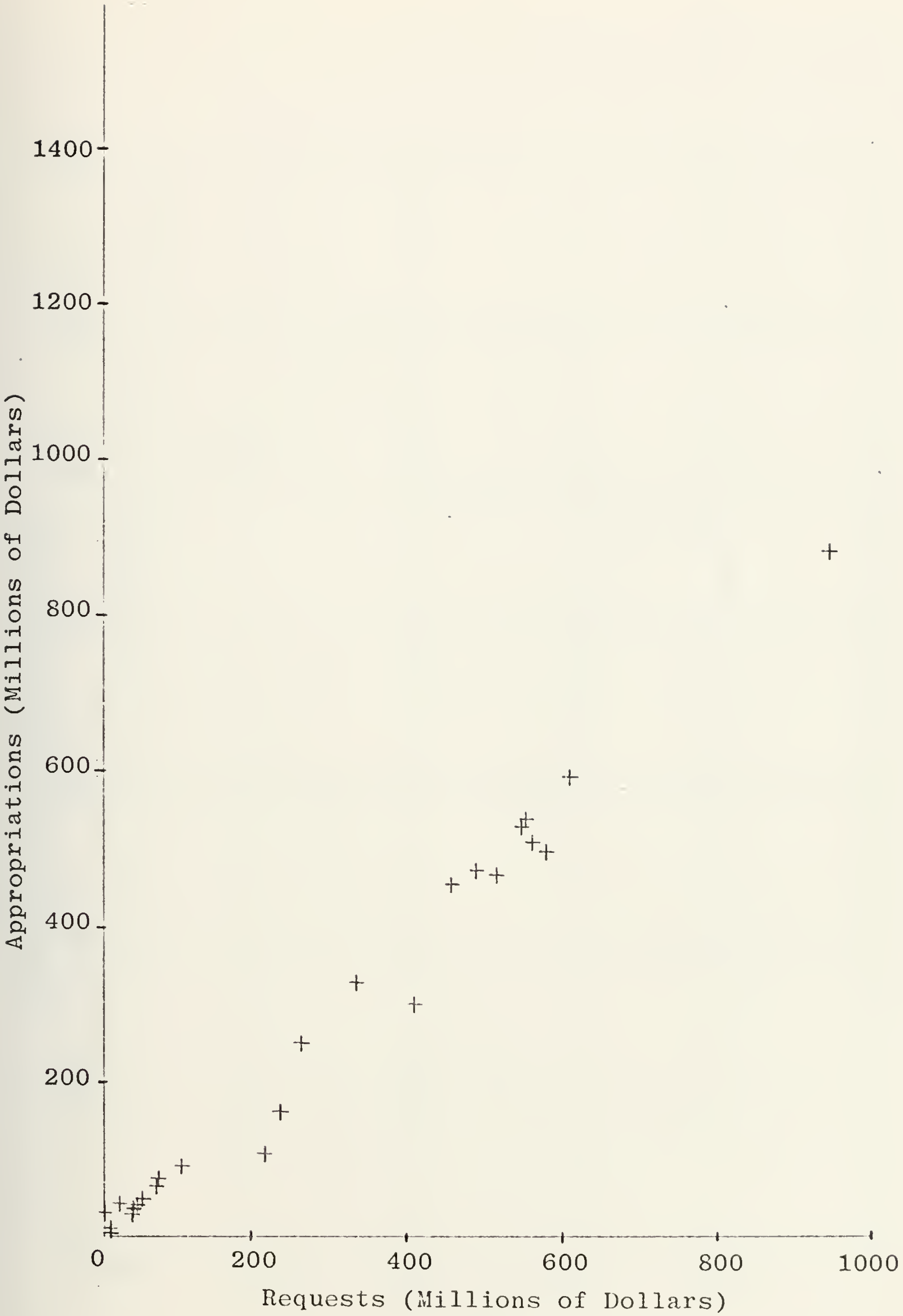



Figure 23. Appropriations vs Requests - Non-Quantity Items, Program Element Level, Procurement: FYs 1970 and 1971

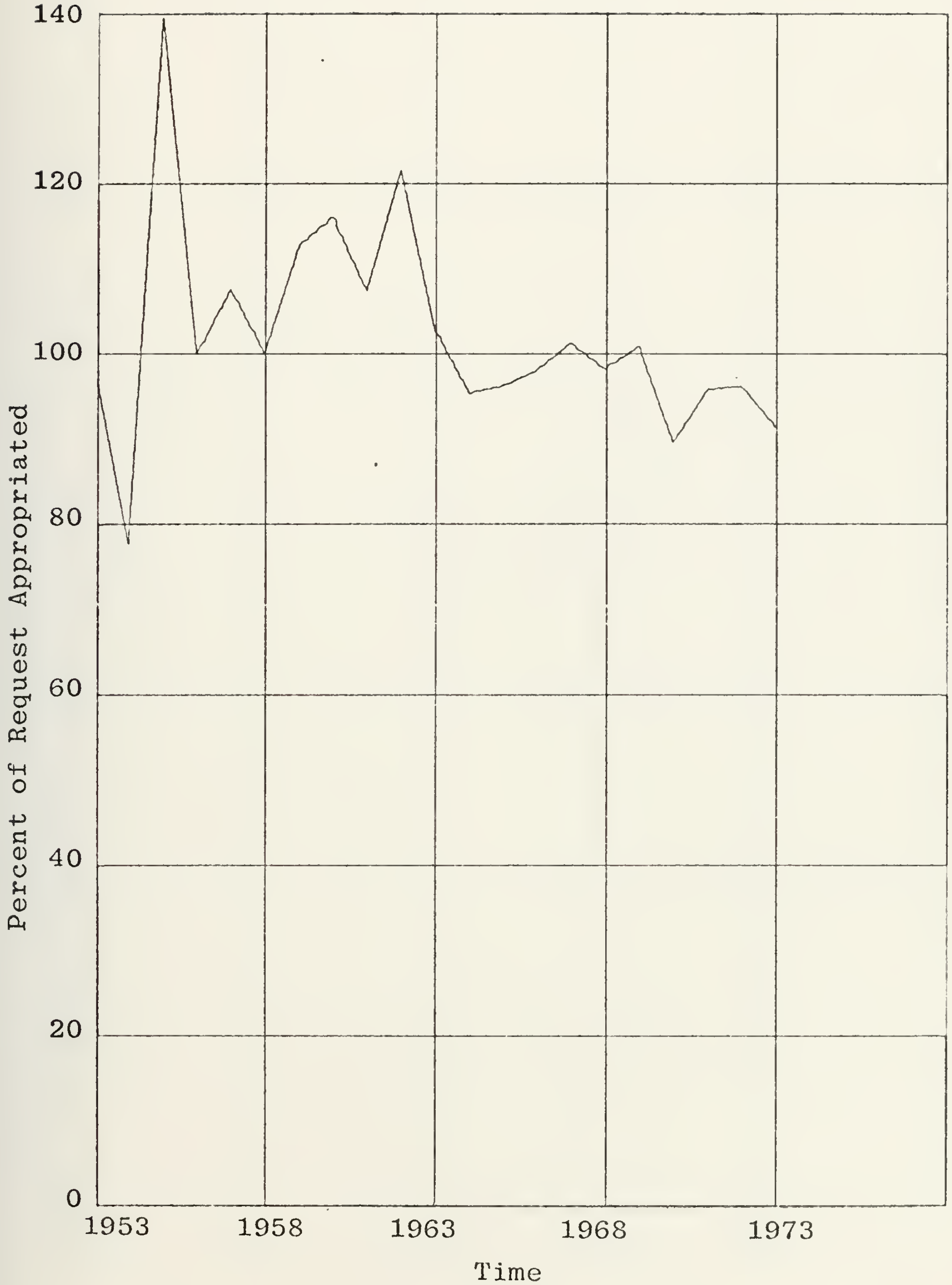



Figure 24. Percent of Request Appropriated vs Time - DoD RDT&E: FYs 1953-1973

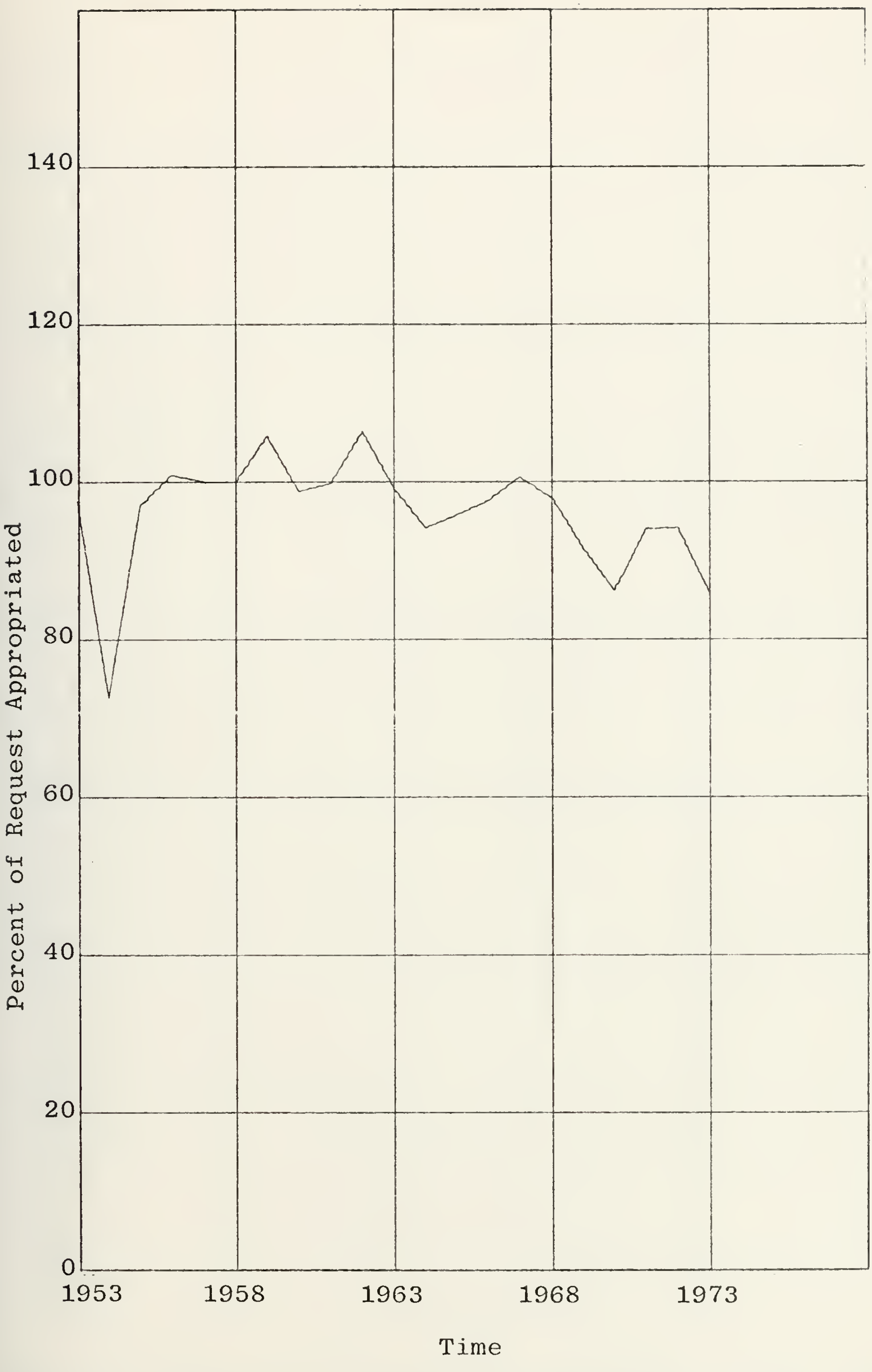



Figure 25. Percent of Request Appropriated vs Time - Army RDT&E: FYs 1953-1973

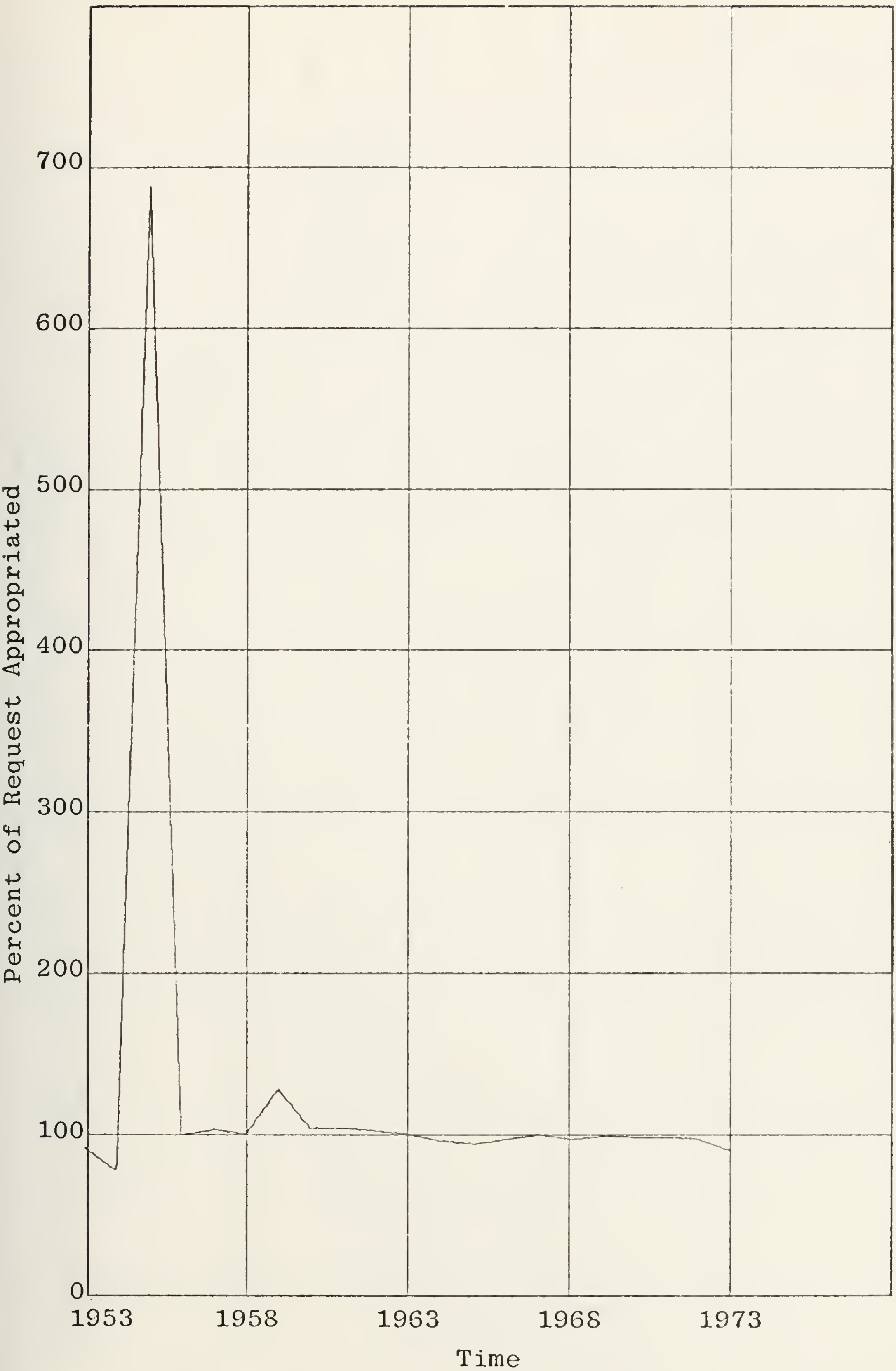



Figure 26. Percent of Request Appropriated vs Time - Navy RDT&E: FYs 1953-1973

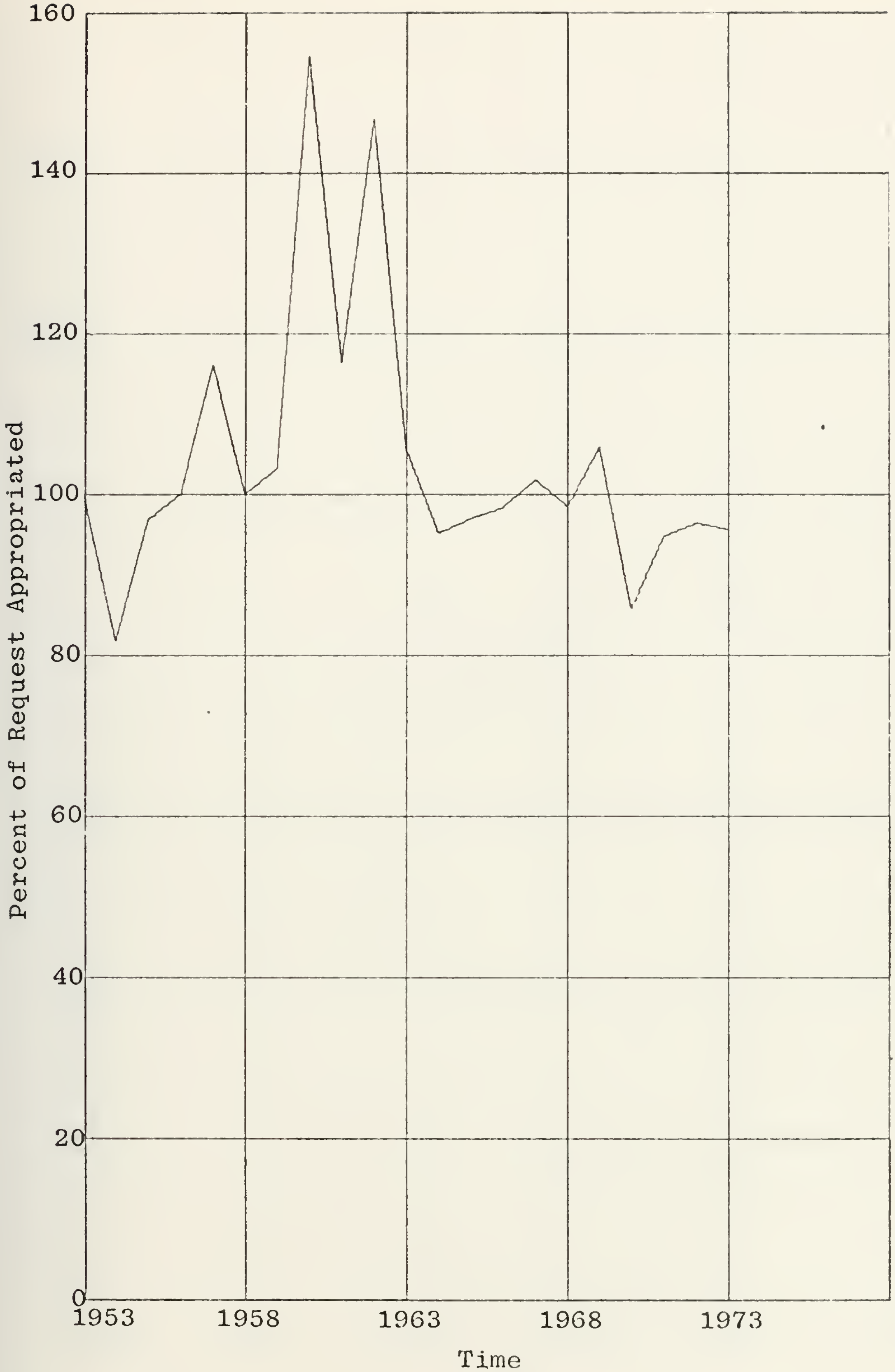



Figure 27. Percent of Request Appropriated vs Time - Air Force RDT&E: FYs 1953-1973

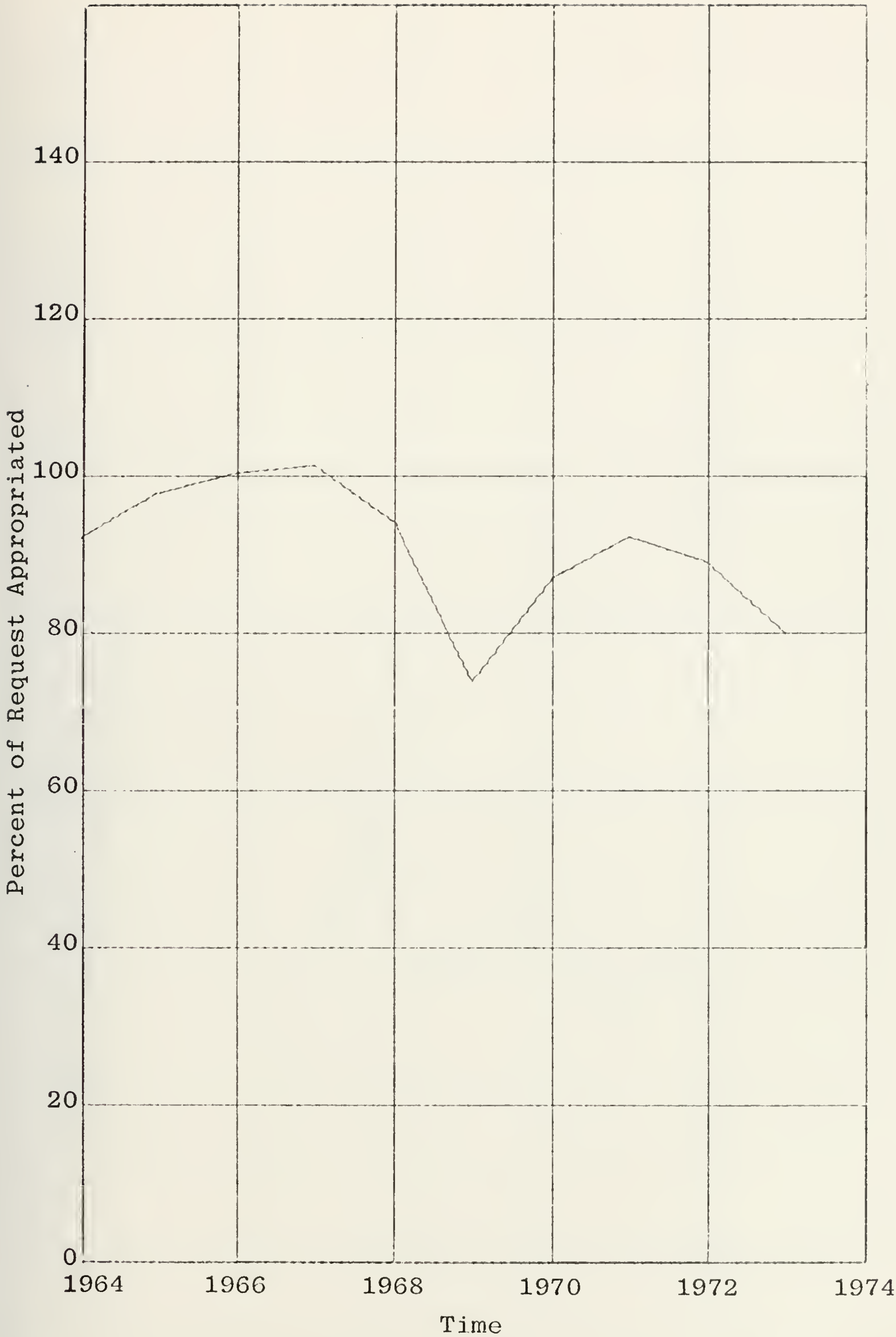



Figure 28. Percent of Request Appropriated vs Time - DoD Procurement: FYs 1964-1973

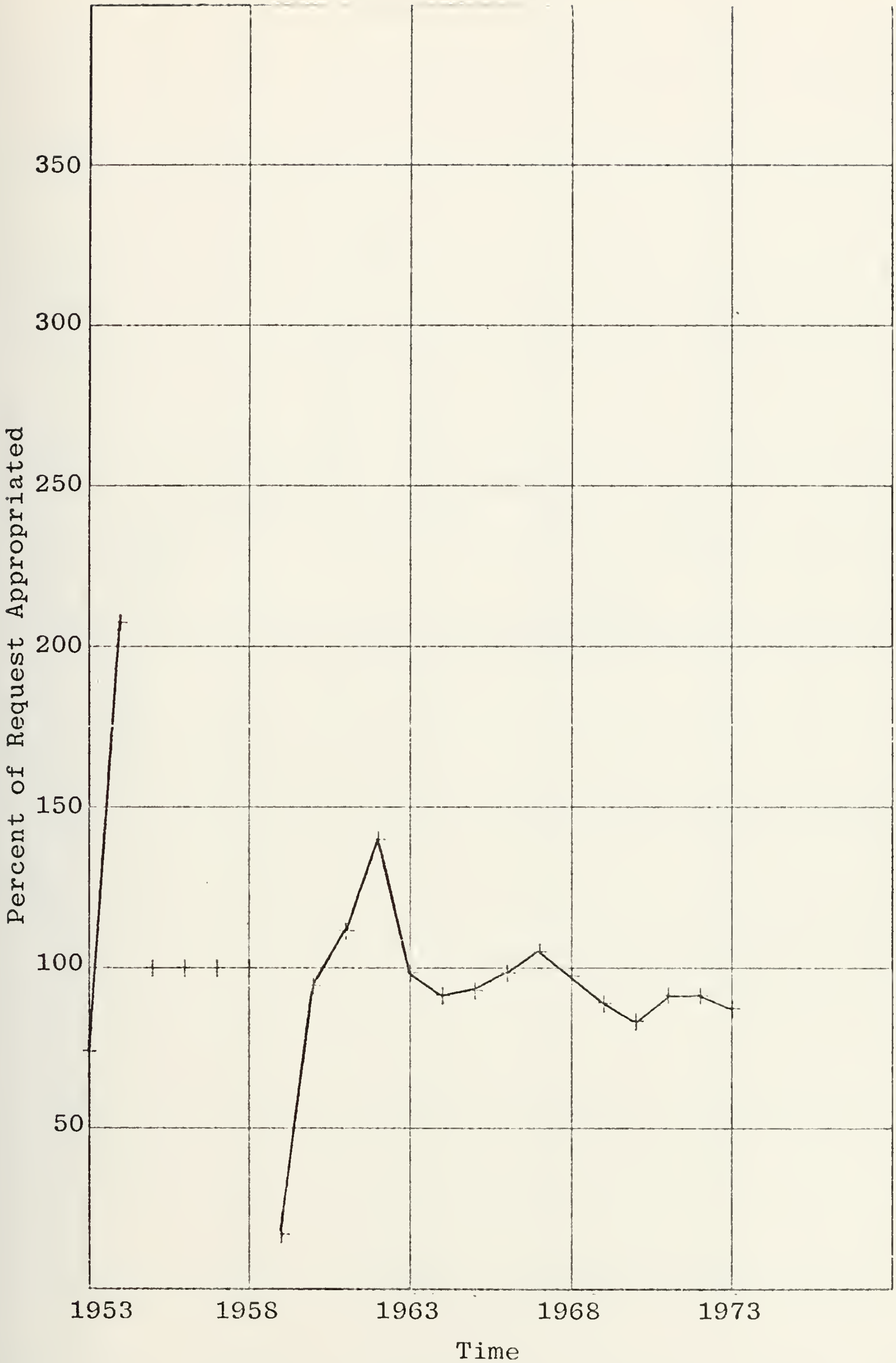



Figure 29. Percent of Request Appropriated vs Time - Procurement Equipment and Missiles, Army: FYs 1953-1973

Note: Data for FYs 1955-1958 missing

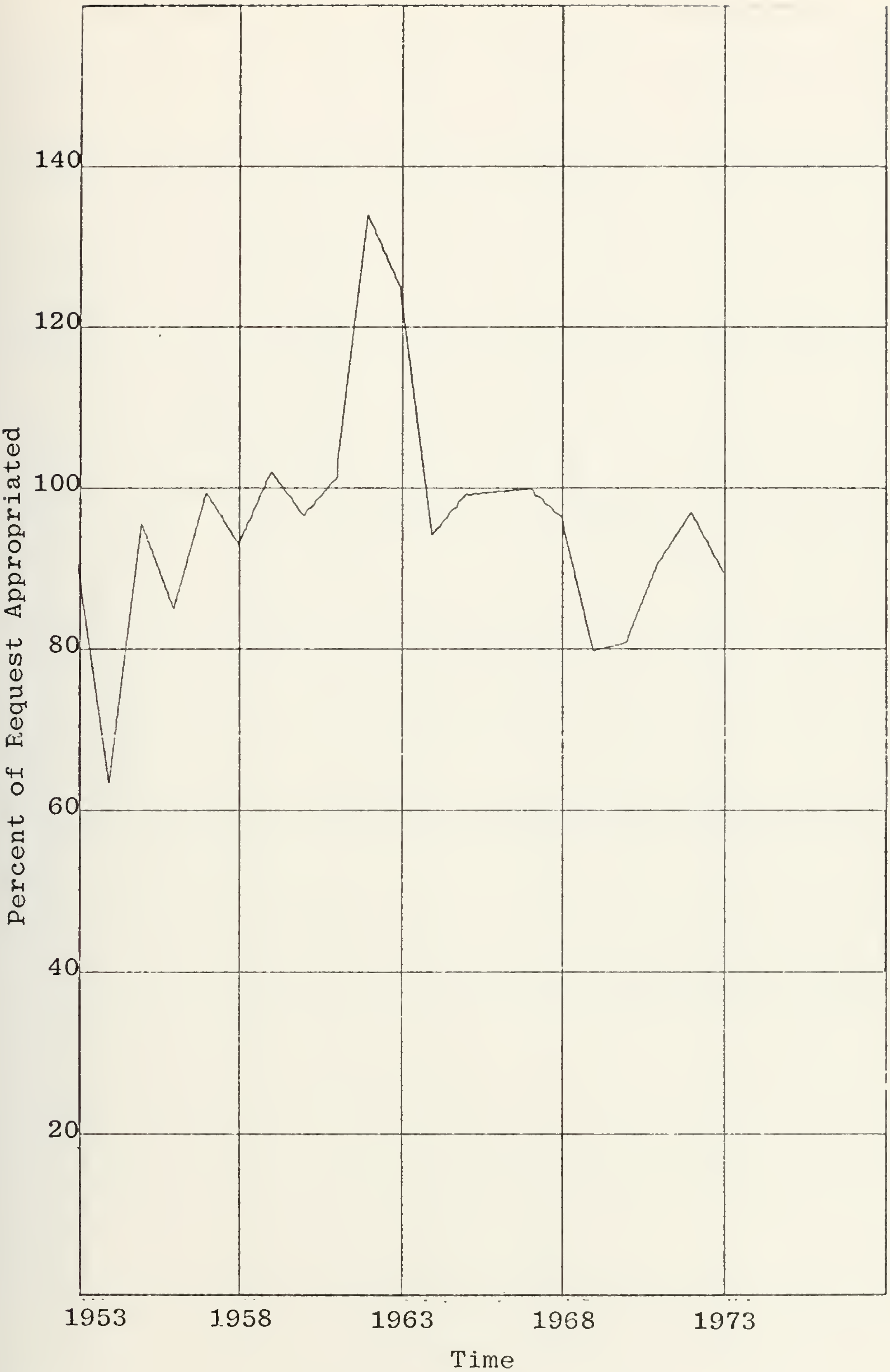



Figure 30. Percent of Request Appropriated vs Time - Procurement Aircraft and Missiles, Navy: FYs 1953-1973


Figure 31. Percent of Request Appropriated vs Time - Procurement Missiles, Air Force: FYs 1953-1973

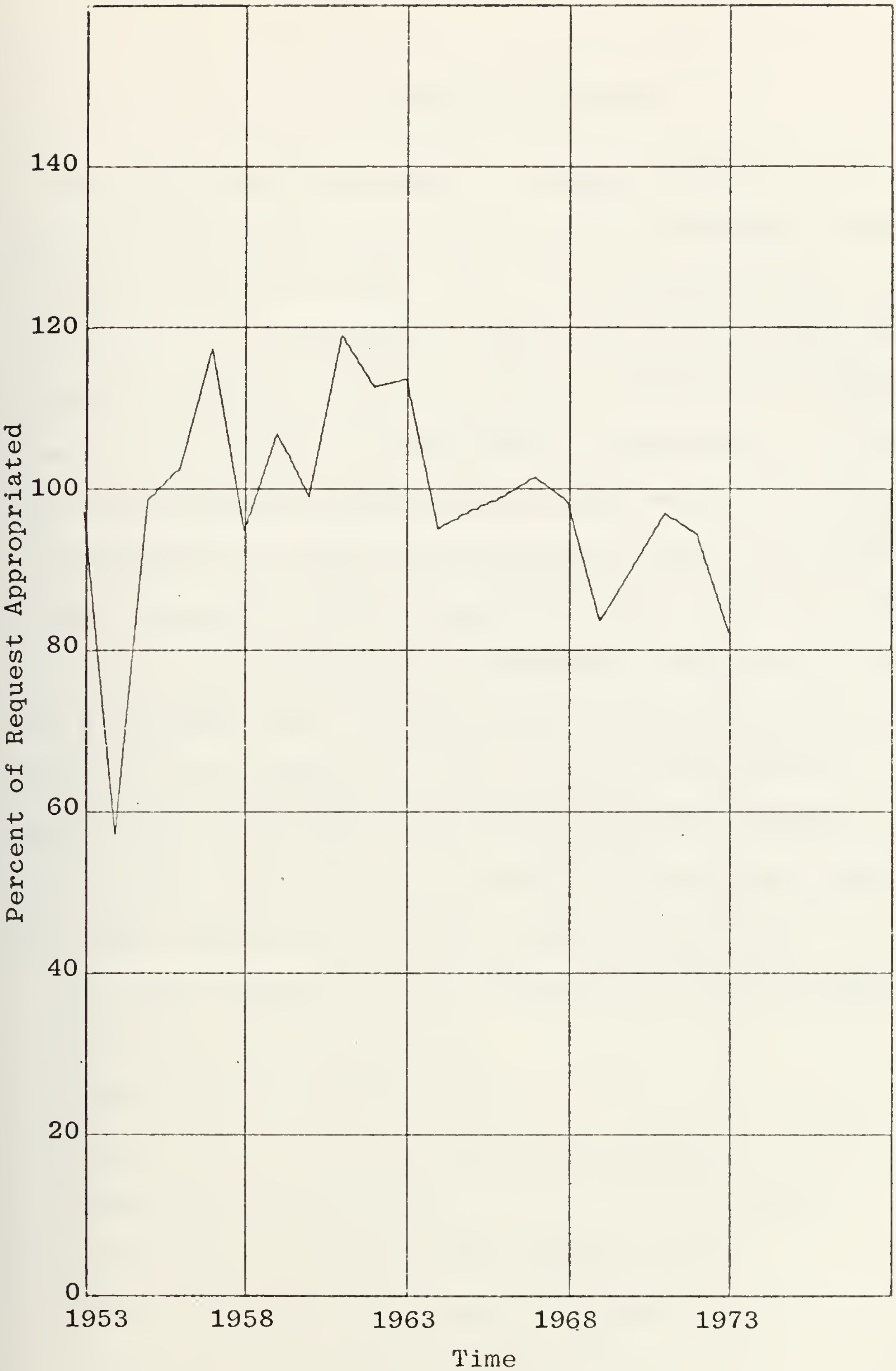



Figure 32. Percent of Request Appropriated vs Time - Procurement Aircraft, Air Force: FYs 1953-1973

# VI. EMPIRICAL RESULTS

Multiple linear regression analysis was used to test the postulated decision rules using the data groupings delineated by the Mann-Whitney tests. Two of the groupings were not investigated -- DoD RDT&E for FYs 1970-1973 and Procurement Aircraft and Missiles Navy -- due to insufficient sample sizes, four and seven observations, respectively. To perform the regression analysis the BIOMED series of statistical programs on multiple and step-wire linear regression was chosen. When the BIOMED programs are used under the assumption of a zero intercept all variances, covariances, standard deviations, and correlations are computed about the origin vice the regression line. The consequences of such a computational procedure have been outlined in Chapter III and, as such, were considered when selecting those models that best describe the defense budgetary process.

As they appeared in their structural form the models were

Model R1 $X_t = \beta_0 Y_{t-1} + \varepsilon_t$

Model R2 $X_t = \beta_1 X_{t-1} + \varepsilon_t$

Model R3 $X_t = \beta_2 Y_{t-1} + \beta_3 (Y_{t-1} - X_{t-1}) + \varepsilon_t$

Model A1 $Y_t = \alpha_0 X_t + \varepsilon_t$

Model A2 $Y_t = \alpha_1 X_t + \alpha_2 (Y_{t-1} - \alpha_1 X_{t-1}) + \varepsilon_t$

Model A3 $Y_t = \alpha_3 X_t + \alpha_4 (X_t - \beta_0 Y_{t-1}) + \varepsilon_t$

Model A4 $Y_t = \alpha_5 X_t + \alpha_6 (X_t - X_{t-1}) + \varepsilon_t$

where: $X_t$ = funding request for year t

$X_{t-1}$ = funding request for year t-1

$Y_t$ = appropriation for year t

$Y_{t-1}$ = appropriation for year t-1

$\varepsilon_t$ = stochastic error term

In this form all models except A2 and A3 were compatible with linear regression format. For A2 the following transformation of variable was necessary:

$$Y_t = \alpha_1 X_t + \alpha_2 (Y_{t-1} - \alpha_1 X_{t-1}) + \varepsilon_t$$

$$= \alpha_1 X_t + \alpha_2 Y_{t-1} - \alpha' X_{t-1} + \varepsilon_t \qquad \text{(A2*)}$$

where $\alpha' = \alpha_2 \times \alpha_1$

The estimated coefficients ($\hat{\alpha}_1$ and $\hat{\alpha}_2$) are consistent in a statistical sense and unbiased but may be unstable (vary with sample size) should the variables $Y_{t-1}$ and $X_{t-1}$ be highly correlated [Ref. 25, p. 159-168].

For model A3 the variable $(X_t - \beta_0 Y_{t-1})$ was estimated by direct substitution of the computed residual from model R1, i.e.

$$Y_t = \alpha_3 X_t + \alpha_4 \{\varepsilon_t(\text{R1})\} + \varepsilon_t \qquad \text{(A3*)}$$

Johnston [Ref. 24, p. 376-380] has pointed out that $\hat{\alpha}_3$ and $\hat{\alpha}_4$ will be unbiased, maximum-likelihood estimates of $\alpha_3$ and $\alpha_4$ if $\varepsilon_t$(R1) is normally distributed.

These models (R1, R2, R3, A1, A2*, A3*, and A4) were applied to the data; the results of which are included in Appendix B, Tables I through VII for RDT&E and VIII through XVII for Procurement. In the case of A2* the coefficients have been transformed back into their structural form.

Of primary importance in deciding which model best fits the data is the impact of suppressing the constant term. For this end, $\bar{\varepsilon} = \frac{1}{n}\sum_{i=1}^{n} \varepsilon_i$ (where $\varepsilon_i$ is the difference between the $i^{th}$ actual and estimated request or appropriation) was computed for each model. For linear models with a constant term $\sum_{i=1}^{n} \varepsilon_i$ will be zero. For the suppressed constant models $\sum_{i=1}^{n} \varepsilon_i$ will be zero if and only if the data falls in a symmetric pattern about the regression line. Other relevant statistics considered were coefficient of variation (CV) and standard error (SE).

Once the more representative models had been identified the statistical significance of the estimated coefficients was tested using the two-sided "t" test at the 0.05 level of significance. Those coefficients annotated by an asterisk (*) in Tables I through XVII were not found to be statistically significant, that is, it was not possible to reject the hypothesis that the coefficient was equal to zero.

Application of the above criteria made possible the selection of the following models as being most representative of the defense budgetary process.

A. RDT&E

Level 1 - Department of Defense FYs 1953-1969

sample size (SS) = 17

$$X_t = \underset{(8.376)}{1.041}Y_{t-1} + \underset{(2.156)}{0.974}(Y_{t-1} - X_{t-1})^{14} + \varepsilon_t; \; CV = 0.063$$

---

[14] The number in parentheses below each coefficient is the computed "t" statistic for that coefficient.

$$Y_t = \underset{(7.497)}{1.011}X_t + \varepsilon_t; \quad CV = 0.084$$

<u>Level 2 - Services</u>

1. <u>Army</u> FYs 1953-1969 SS = 17

$$X_t = \underset{(5.507)}{1.077}Y_{t-1} + \varepsilon_t; \quad CV = 0.152$$

$$Y_t = \underset{(9.397)}{0.984}X_t + \varepsilon_t; \quad CV = 0.050$$

2. <u>Navy</u> FYs 1953-1973 SS = 21

$$X_t = \underset{(7.491)}{1.084}Y_{t-1} + \varepsilon_t; \quad CV = 0.086$$

$$Y_t = \underset{(6.434)}{0.999}X_t + \varepsilon_t; \quad CV = 0.101$$

3. <u>Air Force</u> FYs 1953-1969 SS = 17

$$X_t = \underset{(7.197)}{0.998}Y_{t-1} + \underset{(2.540)}{1.031}(Y_{t-1} - X_{t-1}) + \varepsilon_t; \quad CV = 0.08$$

$$Y_t = \underset{(6.072)}{1.021}X_t + \varepsilon_t; \quad CV = 0.134$$

4. <u>Services Pool (Army, Navy and Air Force)</u>

FYs 1970-1973 SS = 12

$$X_t = \underset{(6.808)}{1.069}Y_{t-1} + \varepsilon_t; \quad CV = 0.082$$

$$Y_t = \underset{(7.849)}{0.931}X_t + \varepsilon_t; \quad CV = 0.054$$

<u>Level 3 - Program</u> FYs 1970-1971 SS = 43

$$X_t = \underset{(4.134)}{0.942}Y_{t-1} + \varepsilon_t; \quad CV = 0.332$$

$$Y_t = \underset{(9.8013)}{0.968}X_t + \varepsilon_t; \quad CV = 0.062$$

Level 4 - Program Element  FYs 1970-1971  SS = 52

$$X_t = \underset{(4.312)}{0.934}Y_{t-1} + \underset{(3.826)}{1.37}(Y_{t-1} - X_{t-1}) + \varepsilon_t; \quad CV = 0.572$$

$$Y_t = \underset{(4.884)}{1.018}X_t + \varepsilon_t; \quad CV = 0.293$$

B. PROCUREMENT

Level 1 - Department of Defense  FYs 1964-1973  SS = 10

$$X_t = \underset{(6.458)}{1.135}Y_{t-1} + \varepsilon_t; \quad CV = 0.095$$

$$Y_t = \underset{(5.049)}{0.899}X_t + \varepsilon_t; \quad CV = 0.106$$

Level 2 - Services

1. Army (PEMA)  FYs 1959-1969  SS = 11

$$X_t = \underset{(3.124)}{1.111}Y_{t-1} + \varepsilon_t; \quad CV = 0.395$$

$$Y_t = \underset{(5.394)}{0.968}X_t + \varepsilon_t; \quad CV = 0.119$$

2. Navy (PAMN)  FYs 1960-1969  SS = 10

$$X_t = \underset{(3.730)}{0.974}Y_{t-1} + \varepsilon_t; \quad CV = 0.221$$

$$Y_t = \underset{(4.492)}{0.999}X_t + \varepsilon_t; \quad CV = 0.160$$

3. Air Force Missiles  FYs 1953-1969  SS = 17

$$X_t = \underset{(3.322)}{0.907}Y_{t-1} + \varepsilon_t; \quad CV = 0.325$$

$$Y_t = \underset{(4.936)}{0.981}X_t + \varepsilon_t; \quad CV = 0.167$$

4. <u>Air Force Aircraft</u> FYs 1953-1969 SS = 17

$$X_t = \underset{(3.369)}{0.880}Y_{t-1}+\varepsilon_t; \quad CV = 0.303$$

$$Y_t = \underset{(5.046)}{0.978}X_t+\varepsilon_t; \quad CV = 0.155$$

5. <u>Services Pooled (PEMA, PAMN, AF A/C & MISS)</u>

FYs 1970-1973 SS = 12

$$X_t = \underset{(4.911)}{1.027}Y_{t-1}+\varepsilon_t; \quad CV = 0.176$$

$$Y_t = \underset{(7.196)}{0.899}X_t+\varepsilon_t; \quad CV = 0.060$$

<u>Level 3 - Program</u> FYs 1970-1971 SS = 23

$$X_t = \underset{(4.029)}{0.883}Y_{t-1}+\varepsilon_t; \quad CV = 0.222$$

$$Y_t = \underset{(6.971)}{0.927}X_t+\varepsilon_t; \quad CV = 0.079$$

<u>Level 4 - Program Element</u> FYs 1970-1972

1. <u>Pooled (NQI and QI)</u> SS = 63

$$X_t = \underset{(3.399)}{0.738}Y_{t-1}+\varepsilon_t; \quad CV = 0.462$$

$$Y_t = \underset{(5.835)}{0.973}X_t+\varepsilon_t; \quad CV = 0.225$$

2. <u>Quantity Items</u> SS = 27

$$X_t = \underset{(1.569)^*}{0.579}Y_{t-1}+\varepsilon_t; \quad CV = 1.233$$

$$Y_t = \underset{(5.227)}{0.963}X_t+\varepsilon_t; \quad CV = 0.304$$

3. <u>Non-Quantity Items</u> SS = 36

$$X_t = \underset{(3.153)}{0.797}Y_{t-1}+\varepsilon_t; \quad CV = 0.372$$

$$Y_t = \underset{(10.674)}{0.990}X_t+\varepsilon_t; \quad CV = 0.041$$

Viewing the results en masse makes it difficult to gain insight into the Congressional-DoD budgetary process. However, when examined in light of some specific hypotheses several interesting points surface.

HYPOTHESIS: <u>THE DEFENSE APPROPRIATION PROCESS MAY BE MODELLED BY SIMPLE (BASICALLY INCREMENTAL) DECISION RULES</u>

Based on their studies of Congressional behavior and empirical results for the non-defense budgetary process Davis, Dempster, and Wildavsky believed that their models were equally applicable to the defense appropriations process. This hypothesis is supported by the results of this thesis for certain levels of aggregation. Of the thirty-four models judged as being most appropriate for the data, thirty-one include only one decision variable. More interesting, however, is the result that the three more complex models are agency request models and in each case $\hat{\alpha}$ - the estimated appropriation coefficient - was greater than 1.0. These were the only cases in which this result was realized.

HYPOTHESIS: <u>SIMPLE LINEAR MODELS ARE NOT VALID FOR THE LOWER LEVELS OF AGGREGATION</u>

One of the criticisms of the Davis, Dempster, and Wildavsky study was that they should have examined object of expenditure classes or some other lower level of aggregation rather than full agency request and subsequent Congressional appropriations. This criticism appears to stem from the belief that aggregation tends to mask Congressional activity and that simple models may not be valid at the lower levels of aggregation.

The empirical results of this study support this belief. If one uses 0.20[15] coefficient of variation as the upper limit on a model's fitting capability then the following observations can be made:

1. simple request models are not adequate for the Program level of aggregation and below for RDT&E and Service level and below for Procurement;
2. simple appropriation models do not adequately fit the data for the Program Element level of aggregation; and
3. simple decision models have better fitting capability for RDT&E than Procurement for all levels of aggregation.

---

[15] "Although the question of reliability of an estimating equation is relative to the context in which the equation is to be used, a value of at least as small as 10 to 20 percent for coefficient of variation is desirable" [Ref. 33, p. 44].

HYPOTHESIS: <u>THE USE OF INCREMENTAL DECISION RULES IS RELATED TO WEAPON SYSTEM VISIBILITY</u>

In their studies of organizational behavior Cyert and March found that organizations attempted to reduce uncertainty by relying more on short-run reaction to feedback from the environment and less on long-range planning [Ref. 10, p. 6]. For the Congress and Defense Department uncertainty may manifest itself in weapon system visibility; that is, the more directly linked a proposed expenditure and a specific weapon system are the less uncertain the benefit of that expenditure. If this hypothesis is true then there should be an inverse relationship between weapon system visibility and coefficient of variation (a measure of model fit).

Intuitively, it seems reasonable to assume that a weapon system is more visible to the Department of Defense than the Congress regardless of the stage of development. Formulation of the Defense budget involves conducting a series of cost-benefit analyses -- the objective of which is to determine the most capable mix of weaponry for the lowest total cost. The technical nature of these studies is of assistance to the services but of little use to the smaller, less technically oriented Congressional appropriation subcommittees.

Visibility of a weapon system is also a function of the funding source within the Defense budget. Research, Development, Test and Evaluation funds support those activities that develop and test conceptual systems whereas Procurement

represents the acquisition of physical hardware. Therefore, in terms of weapon system visibility, Procurement should involve less uncertainty than RDT&E.

Finally, the ability to relate a proposed expenditure to a specific weapon system may be a function of the request itself. For example, consider the Army's request for $38.6M for Modification of Aircraft (FY 1971). For the Army's planning group this request represents modification of a given number and type of aircraft. It also may include contingencies for schedule and material problems; information not readily available to the appropriation committees unless requested. On the other hand, the Army's request for $41.6M for 24 CH-47 Cargo Transport Helicopters identifies the type and unit cost. This type of information allows the appropriation committees to weigh possible alternatives and to determine to some degree the cost-effectiveness of each unit being requested. Thus in terms of relative visibility, it seems plausible to suggest that the uncertainty surrounding non-quantity/type requests should be greater than for quantity/type equipment identified requests.

To test the relationship between relative visibility of a weapon system and model fit the coefficient of variation (CV) for agency request and Congressional appropriation models for Level 3 (Programs) and Level 4 (Program Elements) were ranked according to the previously identified levels of visibility. Level 4 - Procurement was divided into two groups; Quantity Items (those requests that included

quantity/type information) and Non-Quantity Items (no quantity/type information provided with the requests). Figure 33 includes the results of this ordering of model fit.

From Figure 33 it may be concluded that weapon system visibility does have considerable impact upon model fit. Empirical differences in the coefficient of variation for Congressional and agency consideration of the Defense budget at aggregation levels 3 and 4 and Procurement Non-Quantity/Quantity items are consistent with hypothesized results. However, realized differences between RDT&E and Procurement do not conform to hypothesized behavior. In fact, no pattern in coefficient of variation is evident and, therefore, no definite conclusions can be drawn.

## C. OTHER TESTS

### 1. Inflation

Using agency request data as indicative of needs tacitly assumes that inflation has somehow been accounted for. However, a review of available Congressional records and appropriation literature failed to reveal any discussion of the topic of inflation. This omission plus the generally poor fit for agency request models prompted an adjustment of the data to determine if a better fit could be realized.

To this end, data for Model A1, Navy RDT&E was adjusted in the following manner:

Figure 33

Coefficient of Variation vs Weapon System Visibility
Aggregation Levels 3 and 4

A. Level 3 - Program

| Increasing Visibility ↓ | Congress | Agency |
|---|---|---|
| RDT&E | 0.062 | 0.332 |
| PROCUREMENT | 0.079 | 0.222 |

Increasing Visibility →

B. Level 4 - Program Element

| Increasing Visibility ↓ | Congress | Agency |
|---|---|---|
| RDT&E | 0.293 | 0.572 |
| PROCUREMENT | | |
| All Elements Pooled | 0.225 | 0.462 |
| Non-Quantity Items | 0.041 | 0.372 |
| Quantity Items | 0.304 | 1.233 |

Increasing Visibility →

NOTES:

a. CV $\leq$ 0.20 is considered an acceptable model fit

b. The Quantity Item request model coefficient $\hat{\beta}_0$ = 0.57896 is not statistically significant at the .05 level.

$X_t$[inflation factor for year t] = $\beta_0 Y_{t-1}$[inflation factor for year t-1][16]$+\varepsilon_t$

where

the inflation factor for year t = 1/price indice for year t

Regression analysis using this model resulted in

$$X_t = \underset{(7.627)}{1.075} Y_{t-1} + \varepsilon_t \qquad CV = 0.083 \quad SE = 88.392$$

Comparing this with the unadjusted results of

$$X_t = \underset{(7.491)}{1.084} Y_{t-1} + \varepsilon_t \qquad CV = 0.086 \quad SE = 87.313$$

indicated that there was little improvement in model fit. Similar adjustment of Procurement and the data for lower levels of aggregation were equally insignificant.

2. Base Model Concept

Wildavsky noted that appropriation committee members tended to restrict their review of agency budgets to that increment over and above a base or core program [Ref. 41, p. 64-68]. Since none of the Davis, Dempster, and Wildavsky models directly attempt to measure this type of behavior a base model of the form

$$Y_t = \alpha_1 + \alpha_2 (X_t - \alpha_1) + \varepsilon_t \qquad \text{(A5)}$$

was applied to several data sets. In the above model coefficient $\alpha_1$ represents the base or core program exempt from Congressional review and is assumed to be fixed over time.

---

[16] See Figure 34 for price indices and inflation factors used.

Figure 34

Pay and Price Indices/Inflation Factors;
Procurement and RDT&E

| Fiscal Year | Pay and Price Indice, FY 1964 - 1.00, Procurement and RDT&E | Inflation Factor |
|---|---|---|
| 1953 | 0.822 | 1.217 |
| 1954 | 0.806 | 1.241 |
| 1955 | 0.844 | 1.185 |
| 1956 | 0.884 | 1.131 |
| 1957 | 0.943 | 1.060 |
| 1958 | 0.958 | 1.044 |
| 1959 | 0.976 | 1.025 |
| 1960 | 0.973 | 1.028 |
| 1961 | 0.989 | 1.011 |
| 1962 | 0.987 | 1.013 |
| 1963 | 0.993 | 1.007 |
| 1964 | 1.000 | 1.000 |
| 1965 | 1.022 | 0.978 |
| 1966 | 1.042 | 0.960 |
| 1967 | 1.069 | 0.935 |
| 1968 | 1.099 | 0.910 |
| 1969 | 1.140 | 0.877 |
| 1970 | 1.197 | 0.835 |
| 1971 | 1.266 | 0.790 |
| 1972 | 1.317 | 0.759 |
| 1973 | 1.359 | 0.736 |

Source: Department of the Navy Programming Manual

This assumption may not be valid except for small "snapshots" of time. Also, there exists the possibility of a negative base which is unrealistic but may be used as a means of evaluating model validity. On the other hand, model A5 provides for an additional degree of freedom in the regression and should realize a smaller standard error of estimate.

As a basis for comparative analysis Model A5 was applied to Levels 1 and 2 for RDT&E and compared with the results for those models deemed most descriptive of that data. For Level 1 - Department of Defense:

Model A1

$$Y_t = 1.011X_t + \varepsilon_t$$

SE = 310.554   CV = 0.084   $R^2$ = 0.983   $W^2$ = 0.995

$U_B$ = 3.51%   $U_M$ = 5.55%   $U_R$ = 90.94%

Model A5

$$Y_t = 7155.259 + 0.968(X_t - 7155.259) + \varepsilon_t$$

SE = 297.123   CV = 0.073   $R^2$ = 0.985   $W^2$ = 1.00

$U_B$ = 0.00%   $U_M$ = 0.40%   $U_R$ = 99.60%

Durbin-Watson Statistic = 1.367 (cannot reject the hypothesis of no first order autocorrelation)

For Level 2 - Services:

ARMY

Model A1

$$Y_t = 0.934X_t + \varepsilon_t$$

SE = 45.665   CV = 0.050   $R^2$ = 0.991   $W^2$ = 0.998

$U_B$ = 0.009%   $U_M$ = 1.14%   $U_R$ = 98.88%

Model A5

$$Y_t = 192.867+0.970(X_t-192.867)+\varepsilon_t$$

$SE = 52.976$ $CV = 0.054$ $R^2 = 0.998$ $W^2 = 1.00$

$U_B = 0.00\%$ $U_M = 0.29\%$ $U_R = 99.71\%$

Durbin-Watson Statistic = 1.133 (test results for first order autocorrelation are inconclusive).

NAVY

Model A1

$$Y_t = 0.999X_t+\varepsilon_t$$

$SE = 109.110$ $CV = 0.101$ $R^2 = 0.968$ $W^2 = 0.991$

$U_B = 7.93\%$ $U_M = 14.00\%$ $U_R = 78.07\%$

Model A5

$$Y_t = 1434.095+0.916(X_t-1434.095)+\varepsilon_t$$

$SE = 89.550$ $CV = 0.080$ $R^2 = 0.978$ $W^2 = 1.00$

$U_B = 0.00\%$ $U_M = 0.56\%$ $U_R = 99.44\%$

Durbin-Watson Statistic = 2.58 (the hypothesis that there is no first order autocorrelation cannot be rejected).

AIR FORCE

Model A1

$$Y_t = 1.021X_t+\varepsilon_t$$

$SE = 241.283$ $CV = 0.134$ $R^2 = 0.967$ $W^2 = 0.989$

$U_B = 3.54\%$ $U_M = 3.20\%$ $U_R = 93.26\%$

Model A5

$$Y_t = 5927.361+0.975(X_t-5927.361)+\varepsilon_t$$

$SE = 229.007$ $CV = 0.115$ $R^2 = 0.969$ $W^2 = 1.00$

$U_B = 0.00\%$ $U_M = 0.78\%$ $U_R = 99.22\%$

Durbin-Watson Statistic = 1.284 (test results for first order autocorrelation are inconclusive).

Of the above examples, only Army and Navy RDT&E have what may be considered a realistic constant (base program). For DoD and Air Force the large constant term ($7,155M and $5,927M, respectively) implies that ($X_t$ - base program) is negative (i.e., the Congress reviews a negative request for DoD and Air Force RDT&E) which is unrealistic. In these cases the base model does not make sense and possibly indicates that too long a time period was included in the regression. In all cases model fit is comparable to that of the incremental models. Also, while a similar base model was not investigated for agency requests there is no reason to believe that this could not be done. Further research in this area is warranted and should include developing models for separate eras or models with which changes in the base program(s) may be estimated.

# VII. SIGNIFICANCE OF RESULTS AND AREAS SUGGESTED FOR FURTHER STUDY

## A. SIGNIFICANCE OF RESULTS

The word "model" has several shades of meaning, all of which are dependent upon the entity being investigated. In the context of this thesis "model" has been used as a substitute representation of reality, formulated to capture the crux of a complex decision making process but sufficiently free of burdensome detail to enhance understanding. To this end, the tested models (decision rules) have at least partially explained the behavior of Congress in the DoD budgetary process. This qualified judgment as to the adequacy of empirical results is predicated on the adequacy of (1) using a linear model to describe Congressional behavior; (2) fitting techniques, based on the use of least-square regression; and (3) determination of a suitable criterion for measuring model goodness of fit. The degree to which each of these areas impact upon study assumptions affects the relevance of empirical results.

### 1. Linear Models and Congressional Behavior

The concept of simple, predictive decision rules has its origin in sociological theory of bureaucratic organizations [Refs. 10, 30, 32]. Combining theory and observed behavior Davis, Dempster and Wildavsky (DD&W) postulated and tested a series of models (representing simple decision rules) that are strikingly simple -- to the point of being

unrealistic -- yet fit the non-defense appropriation budgetary process very well.

DD&W found that model A1 (using current year request to explain current year appropriation) realized the best fit; a result that was also noted in this study.

More interesting is the effects of aggregation upon model fit; a point not investigated by DD&W or others. As an illustration, consider the empirical results obtained for the period FYs 1970-1971 -- a period short enough to preclude any drastic changes in Congressional behavior:

| | Level of Aggregation | Model | Coefficient of Variation |
|---|---|---|---|
| RDT&E | Service Level (Pooled) | $Y_t=0.9306X_t+\varepsilon_t$ | 0.054 |
| RDT&E | Program Level | $Y_t=0.9678X_t+\varepsilon_t$ | 0.064 |
| RDT&E | Program Element Leval | $Y_t=1.0183X_t+\varepsilon_t$ | 0.293 |
| Procurement | Service Level (Pooled) | $Y_t=0.89869X_t+\varepsilon_t$ | 0.060 |
| Procurement | Program Level | $Y_t=0.92744X_t+\varepsilon_t$ | 0.079 |
| Procurement | Program Element Level | | |
| Procurement | Quantity Items | $Y_t+0.96248X_t+\varepsilon_t$ | 0.304 |
| Procurement | Non-Quantity Items | $Y_t+0.99046X_t+\varepsilon_t$ | 0.041 |

Comparing realized model fit (coefficient of variation) against an upper bound of 0.20 it is evident that the simple model is appropriate for the Program Level of aggregation and above but not for the lowest level of the defense budget -- the program element. This anomaly in the results is difficult to explain in light of the fact that program request and appropriation totals are merely the sum of program element requests and appropriations.

As one means of explaining Committee behavior in light of the empirical results consider the following scenario. Suppose that in the process of balancing the federal budget, the Congress decides to cut the defense budget by "X"%. This total reduction is then distributed among the individual service requests. Allocation of a percentage cut to the services is accomplished via plus and minus reductions in program requests -- again on a percentage basis. Once the magnitude of cut for a particular program has been determined the individual program elements are acted upon in light of information accompaning the requests and/or gained through committee hearings -- with continual comparison of the sum already cut from the program and the total cut to be made. If, after all of the more visible/controversial program elements have been acted upon, there remains an additional amount to be cut from the program then those elements that are of minor importance or have less visibility are cut on a percentage basis.

Committee members' statements, prior research, and the results of this study lend support to the appropriateness of this scenario. First, witness a committee member's views of a submitted budget --

> "There isn't a budget that can't be cut ten percent immediately." [Ref. 19, p. 311];

or how a ranking minority member described his subcommittee markup procedure:

> "Frequently the (subcommittee) chairman has a figure which he states. Sometimes he will have no figure, and he'll turn to me and say, '_______, what do you think?' Maybe I'll have a figure. It's very flexible." [Ref. 19, p. 319].

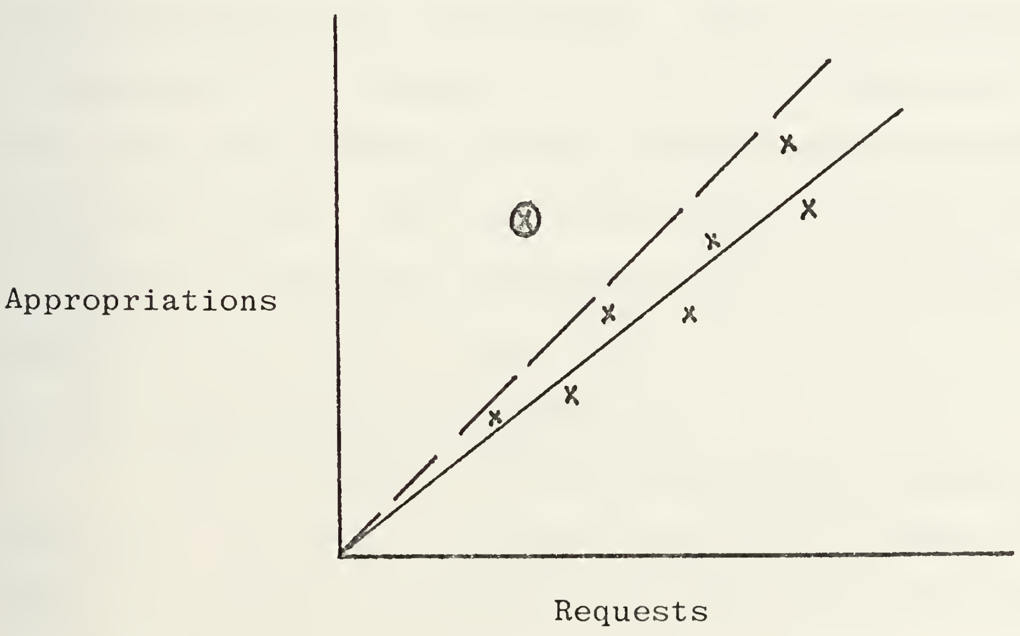
Next, consideration of a portion of the budget by a specific group of subcommittee members is consistent with the committee norm of specialization -- consideration of the budget on an area of interest/expertise basis to insure familiarity with all of the relevant facts [Ref. 11, p. 535]. Finally, the empirical results of this study (and others) support such a scenario. The fact that there is stability in model fit up to and including the program level of aggregation followed by a jump (by a factor of five) in coefficient of variation strongly suggests a change in the method of determining funding levels. Also, the extreme differences in model fit between Quantity Items and Non-Quantity Items -- where determination of the type request was made on the basis of spread sheet information (the same sheets used by the subcommittee) -- speaks for itself.

Without access to committee markup sessions the accuracy of the above scenario cannot be verified. Further study in this area is warranted but will require information currently not available to the public.

2. Least-Squares Estimation Techniques

Use of least-squares estimation techniques assumes no interdependence between either the coefficient(s) being estimated and the independent variable(s) or between the independent variable(s) and the error term. These are

assumptions that may not always be valid. For example, if the Congress is using a percentage appropriation decision rule, it may be the case that the percentage changes when a request is considered exorbitant or inadequate in light of an evolving international crisis; Navy-RDT&E for FY 1955 being an example of the latter (Request - $61.0M, Appropriation - $419.9M). Model A2 was designed to account for such behavior; the results of which were judged insignificant mainly due to small sample sizes with relatively few major deviations from the norm. As such, these major deviations remain unaccounted for. More significant is the effect that these outliers have upon the estimated appropriation coefficients. As an illustration, consider the situation portrayed below.



The circled observation may be a genuine outlier in that the Congress, in response to a critical international crisis, appropriated an amount in excess of the normal percentage (similar to that observed for FY 1955 Navy RDT&E). Because least-squares attempts to minimize the squared deviations from the regression line the fitted curve (solid line) will be rotated counterclockwise (dashed line). As such, the estimate of the coefficient will be somewhat contaminated by the single outlier. Deleting the outlier(s) is one possible means of resolving this problem but then the question becomes one of determining which observations are outliers and which belong in the analysis.

Another more basic problem is that, since the regression line is forced through the origin and negative requests (appropriations) are not possible, there is a certain lack of homogeneity of variance built into the DD&W models. The most promising solution to this problem appears to be the fixed base model. An alternative solution may be to employ a different regression methodology such as that suggested by Capra in his Doctoral thesis [Ref. 2].

### 3. Determination of Model Fit

Prior analyses have used coefficient of determination ($R^2$) as a means of judging model fit to budget data. There are two major problems with using this criterion; one being associated with computing $R^2$ for the DD&W models while the other is peculiar to the subject matter being investigated. The computational problem has been discussed in Chapter IV.

A more basic problem has been revealed by Capra [Ref. 2] and is associated with the usefulness of $R^2$ as a tool for analyzing budget models similar to those suggested by DD&W. As an illustration, consider the model

$$(1) \qquad Y_t = \beta X_t + \varepsilon_t$$

which states that, on the average, the Congress appropriates a percentage ($\beta$) of the request. There is no difference between this and

$$(2) \qquad (X_t - Y_t) = CX_t + \eta_t$$

which states that, on the average, the Congress cuts a certain percentage (C) of the request. In fact, if (1) is the correct model, then $\beta$ should equal (1-C) and $\varepsilon_t$ should equal $\eta_t$ since

$$(X_t - Y_t) = CX_t + \eta_t \quad \text{implies that}$$

$$Y_t = (1-C)X_t + \eta_t \equiv \beta X_t + \varepsilon_t$$

Theoretically one should be able to test either model and obtain similar results. In reality such is not always the case. In preliminary tests, a data sample that yielded $W^2=0.98$ for model (1) resulted in $W^2=0.23$ for model (2). The problem is that $R^2$ or $W^2$ should be considered in a probabilistic context (which is possible -- but hasn't been done for DD&W models).

As a surrogate measure of model fit coefficient of variation has been used throughout this analysis; primarily

due to its robustness to distributional assumptions of the error terms and deletion (inclusion) of a constant term in the regression equation. As such, CV is a reliable indicator of model fit. For the same data in which $W^2$ varied from 0.98 to 0.23 CV remained at 0.103 for both regressions.

## B. AREAS SUGGESTED FOR FURTHER STUDY

Cross-sectional and time-series regression analyses have been used to investigate the applicability of the Davis, Dempster, and Wildavsky models to the Defense budgetary process. The following is a summary of the areas that the author feels needs to be investigated further.

1) The DD&W models appear to be valid for the Defense budgetary process at the higher levels of aggregation. Specifically, simple request decision rules achieved an acceptable fit to the data down to the Service level of aggregation and simple appropriation decision rules fit the data down to the Program level. Neither fit the lowest level of aggregation of the Defense budget -- the Program Element. This anomaly remains to be explained.

2) The DD&W models were unable to account for major deviations in the stream of requests or appropriations. Empirical results for the autoregressive model A2 were insignificant mainly due to saml1 sample sizes. Therefore, since least squares estimation was used, those data sets that contain major deviations probably tend to overestimate or underestimate the true percentage appropriated. Further

study of committee behavior is necessary to determine why and when such deviations occur.

3) The applicability of simple decision models appears to be a function of weapon system visibility, that is, as a weapon system and proposed expenditure become more directly linked a simple decision model of the kind investigated here becomes less appropriate. This result was noted by examining differences in model fit between agency requests and Congressional reaction to those requests and by comparing requests (appropriations) that included equipment type/quantity with requests (appropriations) that are of a more general (or non-quantity) nature at the Program Element level of aggregation for Procurement. This result may appear to encourage reduced system visibility by defense agencies to ensure predictable funding. Such is not the case. All that is implied is that a decision rule other than a percentage of request rule appears to be used for the more visible weapon systems. Further study as to why the Congress tends to employ different decision rules is necessary before definitive conclusions can be made in this area.

4) Finally, questions have been raised about the validity of a model's statistical properties and test results when using linear models with a suppressed constant term. A survey of available theory on linear regression analysis revealed that few textbooks addressed the subject explicitly and those that did approached the topic in general terms.

Further research in this area is required to establish the statistical properties of incremental models and appropriate test procedures.

## APPENDIX A

## RESULTS OF MANN-WHITNEY TESTS FOR DATA HOMOGENEITY

The Mann-Whitney U Test was used to test the periods FYs 1953-1959, FYs 1960-1969, and FYs 1970-1973. Under the null hypothesis the data subsets are drawn from the same population ($H_0 : G(X) = F(X)$). To test this hypothesis the sample observations are pooled and ranked according to increasing size. The value of the U-statistic is computed as follows:

$$T = S-(n_1)(n_1+1)/2$$ (See Chapter III-B-2 for definition of terms)

If T is less than or equal to $U_{(n_1, n_2, \alpha)}$ where $\alpha$ is the desired significance level then the null hypothesis ($H_0$) is rejected.

To account for the three subsets, FYs 1953-1959 and FYs 1960-1969 were first compared. Then, based on this outcome FYs 1970-1973 was tested against FYs 1953-1969 ($H_0$ is not rejected) or FYs 1960-1969 ($H_0$ rejected). From these tests the following numerical results were realized.

A. RDT&E

1. Department of Defense

a. FYs 1953-1959 vs FYs 1960-1969

$T = 28.0 \quad U_{(7, 10, .10)} = 22.0$ ($H_0$ cannot be rejected)

b. FYs 1953-1969 vs FYs 1970-1973

$T = 15.0 \quad U_{(4, 17, .10)} = 19.0$ (reject $H_0$)

2. Services

Army

a. FYs 1953-1959 vs FYs 1960-1969

$T = 29.0 \quad U_{(7,10,.10)} = 22.0$ ($H_0$ cannot be rejected)

b. FYs 1953-1969 vs FYs 1970-1973

$T = 5.0 \quad U_{(4,17,.10)} = 19.0$ (reject $H_0$)

Navy

a. FYs 1953-1969 vs FYs 1960-1969

$T = 30.0 \quad U_{(7,10,.10)} = 22.0$ ($H_0$ cannot be rejected)

b. FYs 1953-1969 vs FYs 1970-1973

$T = 20.0 \quad U_{(4,17,.10)} = 19.0$ ($H_0$ cannot be rejected)

Air Force

a. FYs 1953-1959 vs FYs 1960-1969

$T = 24.0 \quad U_{(7,10,.10)} = 22.0$ ($H_0$ cannot be rejected)

b. FYs 1953-1969 vs FYs 1970-1973

$T = 18.0 \quad U_{(4,17,.10)} = 19$ (reject $H_0$)

Services Pooled FYs 1970-1973

a. Army vs Navy

$T = 5.0 \quad U_{(4,4,.10)} = 4.0$ ($H_0$ cannot be rejected)

b. Army and Navy vs Air Force

$T = 10.0 \quad U_{(4,8,.10)} = 8.0$ ($H_0$ cannot be rejected)

## B. PROCUREMENT

### 1. Department of Defense

a. FYs 1964-1969 vs FYs 1970-1973

$T = 7.0 \quad U_{(4,6,.10)} = 6.0$ ($H_0$ cannot be rejected)

### 2. Services

Army-PEMA

a. FYs 1953-1959 vs FYs 1960-1969

$T = 30.0 \quad U_{(3,10,.10)} = 7.0$[17] ($H_0$ cannot be rejected)

b. FYs 1953-1969 vs FYs 1970-1973

$T = 4.0 \quad U_{(4,14,.10)} = 16$ (reject $H_0$)

Navy-PAMN

a. FYs 1953-1959 vs FYs 1960-1969

$T = 12 \quad U_{(7,10,.10)} = 22.0$ (reject $H_0$)

b. FYs 1960-1969 vs FYs 1970-1973

$T = 8.0 \quad U_{(4,10,.10)} = 11.0$ (reject $H_0$)

Air Force-Aircraft

a. FYs 1953-1959 vs FYs 1960-1969

$T = 25 \quad U_{(7,10,.10)} = 22.0$ ($H_0$ cannot be rejected)

b. FYs 1953-1969 vs FYs 1970-1973

$T = 9.0 \quad U_{(4,17,.10)} = 19.0$ (reject $H_0$)

---

[17] Data for FYs 1955-1958 missing. As a result the period FYs 1953-1959 contained only three observations.

Air Force-Missiles

a. FYs 1953-1959 vs FYs 1960-1969

$T = 24.0 \quad U_{(7,10,.10)} = 22.0$ ($H_0$ cannot be rejected)

b. FYs 1953-1969 vs FYs 1970-1973

$T = 14.0 \quad U_{(4,17,.10)} = 19$ (reject $H_0$)

Services Pooled FYs 1970-1973

a. Air Force Aircraft vs Air Force Missiles

$T = 6.0 \quad U_{(4,4,.10)} = 4.0$ ($H_0$ cannot be rejected)

b. Air Force Aircraft & Missiles vs Army PEMA

$T = 10.0 \quad U_{(4,8,.10)} = 8.0$ ($H_0$ cannot be rejected)

c. Air Force Aircraft & Missiles, Army PEMA vs Navy PAMN

$T = 18.0 \quad U_{(4,12,.10)} = 14.0$ ($H_0$ cannot be rejected)

# APPENDIX B

TABLE I

Empirical Results for Aggregation Level 1 Department of Defense RDT&E; FYs 1953-1969

| Model | $\alpha_1/\beta_1$ (t-value) | $\alpha_2/\beta_2$ (t-value) | SE | CV | $W^2$ | $\bar{\varepsilon}$ | $R^2$ | $U_B$(%) | $U_M$(%) | $U_R$(%) |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 1.062<br>(6.889) | -- | 308.051 | 0.101 | 0.993 | 51.632 | 0.974 | 1.98 | 2.25 | 95.77 |
| R2 | 1.073<br>(5.1619) | -- | 678.819 | 0.179 | 0.978 | 128.632 | 0.919 | 3.85 | 2.97 | 93.18 |
| R3 | 1.0414<br>(8.3758) | 0.9741<br>(2.1560) | 237.771 | 0.063 | 0.998 | 17.000 | 0.990 | 0.59 | 0.62 | 98.79 |
| A1 | 1.011<br>(7.4966) | -- | 310.554 | 0.084 | 0.995 | 56.297 | 0.983 | 3.51 | 5.55 | 90.94 |
| A2 | 1.0056<br>(7.3602) | 0.3681<br>(0.7113)* | 311.557 | 0.084 | 0.996 | 54.724 | 0.983 | 3.56 | 6.72 | 89.72 |
| A3 | 1.0015<br>(7.3392 | 0.3626<br>(0.7770)* | 302.717 | 0.078 | 0.996 | 52.457 | 0.984 | 3.46 | 6.60 | 89.94 |
| A4 | 0.9925<br>(7.1854) | 0.2110<br>(0.5972)* | 292.854 | 0.072 | 0.997 | 48.988 | 0.986 | 3.19 | 6.46 | 90.35 |

* indicates that the variable may not be considered statistically different from zero.

TABLE II

Empirical Results for Aggregation Level 2 Army RDT&E; FYs 1953-1969

| Model | $\alpha_1/\beta_1$ (t-value) | $\alpha_2/\beta_2$ (t-value) | SE | CV | $W^2$ | $\bar{\varepsilon}$ | $R^2$ | $U_B$(%) | $U_M$(%) | $U_R$(%) |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 1.0770 (5.507) | -- | 145.819 | 0.152 | 0.983 | 21.758 | 0.914 | 2.39 | 2.44 | 95.17 |
| R2 | 1.052 (5.094) | -- | 166.944 | 0.174 | 0.977 | 21.479 | 0.887 | 1.77 | 0.89 | 97.33 |
| R3 | 1.0882 (5.455) | 0.8261 (0.9167)* | 145.640 | 0.152 | 0.984 | 24.769 | 0.921 | 3.34 | 4.60 | 92.06 |
| A1 | 0.9839 (9.3970) | -- | 45.665 | 0.050 | 0.998 | -1.1367 | 0.991 | 0.09 | 1.14 | 98.77 |
| A2 | 0.9833 (9.0831) | 0.1694 (0.3231)* | 48.348 | 0.051 | 0.998 | -0.488 | 0.991 | 0.01 | 0.48 | 99.51 |
| A3 | 0.9836 (9.0061) | 0.0169 (0.0560)* | 48.985 | 0.052 | 0.998 | -1.143 | 0.991 | 0.10 | 1.24 | 98.66 |
| A4 | 0.9721 (8.1725) | 0.0319 (0.1043)* | 54.677 | 0.056 | 0.998 | 1.1204 | 0.989 | 0.05 | 0.01 | 99.94 |

* indicates that the variable may not be considered statistically different from zero.

TABLE III

Empirical Results for Aggregation Level 2 Navy RDT&E; FYs 1953-1973

| Model | $\alpha_1/\beta_1$ (t-value) | $\alpha_2/\beta_2$ (t-value) | SE | CV | $W^2$ | $\bar{\varepsilon}$ | $R^2$ | $U_B$(%) | $U_M$(%) | $U_R$(%) |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 1.084 (7.491) | -- | 87.313 | 0.086 | 0.995 | 6.844 | 0.797 | 0.66 | 0.46 | 98.88 |
| R2 | 1.088 (5.570) | -- | 157.523 | 0.155 | 0.983 | 40.790 | 0.937 | 7.19 | 9.81 | 83.00 |
| R3 | 1.0829 (7.332) | 0.8625 (0.1860)* | 90.058 | 0.089 | 0.995 | 5.029 | 0.979 | 0.36 | 0.10 | 99.54 |
| A1 | 0.9999 (6.4435) | -- | 109.110 | 0.101 | 0.991 | 29.753 | 0.968 | 7.93 | 14.00 | 78.07 |
| A2 | 0.9990 (6.1834) | 0.0686 (0.1295)* | 116.923 | 0.112 | 0.991 | 30.704 | 0.962 | 7.96 | 17.93 | 74.11 |
| A3 | 0.9978 (6.3515) | 0.3986 (0.6814)* | 111.517 | 0.107 | 0.992 | 31.462 | 0.966 | 9.19 | 21.69 | 69.12 |
| A4 | 0.9818 (5.6404) | 0.1726 (0.3827)* | 110.139 | 0.102 | 0.993 | 21.116 | 0.971 | 6.93 | 15.65 | 77.42 |

* indicates that the variable may not be considered statistically different from zero.

TABLE IV

Empirical Results for Aggregation Level 2 Air Force RDT&E; FYs 1953-1969

| Model | $\alpha_1/\beta_1$ (t-value) | $\alpha_2/\beta_2$ (t-value) | SE | CV | $W^2$ | $\bar{\varepsilon}$ | $R^2$ | $U_B$(%) | $U_M$(%) | $U_R$(%) |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 1.038 (5.548) | -- | 285.243 | 0.158 | 0.984 | 28.534 | 0.953 | 1.07 | 0.14 | 98.79 |
| R2 | 1.053 (4.088) | -- | 522.512 | 0.290 | 0.947 | 98.825 | 0.846 | 3.83 | 0.51 | 95.66 |
| R3 | 0.9986 (7.197) | 1.0312 (2.5397) | 147.838 | 0.082 | 0.996 | 3.7006 | 0.988 | 0.07 | 0.03 | 99.90 |
| A1 | 1.0211 (6.0718) | -- | 241.283 | 0.134 | 0.989 | 43.128 | 0.967 | 3.54 | 3.20 | 93.26 |
| A2 | 1.0086 (5.9340) | 0.4223 (0.8199)* | 239.084 | 0.126 | 0.991 | 48.090 | 0.970 | 4.75 | 5.49 | 89.76 |
| A3 | 1.0085 (5.6167) | 0.2332 (0.4699)* | 250.662 | 0.133 | 0.989 | 49.535 | 0.966 | 4.51 | 4.88 | 90.61 |
| A4 | 1.0119 (5.9776) | 0.1612 (0.4449)* | 239.418 | 0.120 | 0.991 | 43.495 | 0.969 | 3.77 | 4.42 | 91.81 |

* indicates that the variable may not be considered statistically different from zero.

TABLE V

Empirical Results for Aggregation Level 2 — Army, Navy, and Air Force RDT&E (Pooled); FYs 1970-1973

| Model | $\alpha_1/\beta_1$ (t-value) | $\alpha_2/\beta_2$ (t-value) | SE | CV | $W^2$ | $\bar{\varepsilon}$ | $R^2$ | $U_B$(%) | $U_M$(%) | $U_R$(%) |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 1.0695 (6.8075) | -- | 204.825 | 0.082 | 0.994 | 30.865 | 0.885 | 2.48 | 22.67 | 74.85 |
| R2 | 1.0234 (5.7320) | -- | 275.607 | 0.110 | 0.989 | 28.883 | 0.788 | 1.20 | 5.47 | 93.33 |
| R3 | 1.0714 (6.1869) | 0.0477 (0.0777)* | 214.650 | 0.086 | 0.987 | 31.481 | 0.885 | 2.58 | 23.85 | 73.57 |
| A1 | 0.9306 (7.8485) | -- | 125.097 | 0.054 | 0.998 | 4.089 | 0.948 | 0.12 | 0.14 | 99.74 |
| A2 | 0.9385 (7.5288) | -0.2624 (-0.5435)* | 123.601 | 0.053 | 0.998 | 0.682 | 0.954 | 0.00 | 0.67 | 99.33 |
| A3 | 0.9808 (7.6591) | -0.0317 (-0.0723)* | 131.026 | 0.054 | 0.998 | 4.605 | 0.948 | 0.15 | 0.32 | 99.53 |
| A4 | 0.9346 (7.6235) | -0.1190 (-0.3150)* | 126.672 | 0.054 | 0.998 | 4.373 | 0.952 | 0.14 | 0.32 | 99.34 |

* indicates that the variable may not be considered statistically different from zero.

TABLE VI

Empirical Results for Aggregation Level 3 RDT&E Programs; FYs 1970-1971

| Model | $\alpha_1/\beta_1$ (t-value) | $\alpha_2/\beta_2$ (t-value) | SE | CV | $W^2$ | $\bar{\varepsilon}$ | $R^2$ | $U_B$(%) | $U_M$(%) | $U_R$(%) |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 0.9419<br>(4.1338) | -- | 102.962 | 0.332 | 0.940 | 21.437 | 0.867 | 4.54 | 0.25 | 95.21 |
| R2 | 0.8409<br>(3.2900) | -- | 140.987 | 0.454 | 0.887 | 27.776 | 0.749 | 4.06 | 0.12 | 95.82 |
| R3 | 0.9614<br>(4.1105) | 0.2795<br>(0.5516)* | 102.511 | 0.330 | 0.943 | 23.659 | 0.876 | 5.86 | 0.73 | 93.41 |
| A1 | 0.9678<br>(9.8013) | -- | 18.786 | 0.062 | 0.998 | 0.759 | 0.995 | 0.17 | 0.02 | 99.81 |
| A2 | 0.9629<br>(10.0502) | 0.1086<br>(0.4978)* | 17.191 | 0.057 | 0.998 | 1.915 | 0.996 | 1.36 | 1.06 | 97.58 |
| A3 | 0.9709<br>(10.1113) | -0.0764<br>(-0.3944)* | 17.519 | 0.059 | 0.998 | 0.979 | 0.996 | 0.34 | 0.13 | 99.53 |
| A4 | 0.96738<br>(9.6362) | -0.0074<br>(-0.0459)* | 19.213 | 0.064 | 0.998 | 0.696 | 0.995 | 0.14 | 0.01 | 99.85 |

* indicates that the variable may not be considered statistically different from zero.

TABLE VII

Empirical Results for Aggregation Level 4 RDT&E Program Elements; FYs 1970-1971

| Model | $\alpha_1/\beta_1$ (t-value) | $\alpha_2/\beta_2$ (t-value) | SE | CV | $W^2$ | $\bar{\varepsilon}$ | $R^2$ | $U_B$(%) | $U_M$(%) | $U_R$(%) |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 0.9080 (4.0712) | -- | 29.615 | 0.617 | 0.867 | 4.090 | 0.798 | 1.94 | 1.73 | 96.33 |
| R2 | 0.5284 (1.9746) | -- | 56.531 | 1.178 | 0.516 | 15.270 | 0.305 | 7.44 | 9.14 | 83.42 |
| R3 | 0.9343 (4.312) | 1.1367 (3.8262) | 27.478 | 0.572 | 0.888 | 5.564 | 0.833 | 4.27 | 0.37 | 95.36 |
| A1 | 1.0183 (4.884) | -- | 20.000 | 0.293 | 0.977 | -4.968 | 0.965 | 6.65 | 9.94 | 83.41 |
| A2 | 0.9521 (3.386) | 0.3770 (0.6147)* | 19.997 | 0.256 | 0.979 | -3.274 | 0.967 | 3.13 | 5.76 | 91.11 |
| A3 | 0.8384 (1.5665) | 0.7261 (1.1491)* | 18.431 | 0.236 | 0.982 | -7.426 | 0.975 | 18.08 | 20.76 | 61.16 |
| A4 | 0.9769 (3.9882) | 0.35224 (0.5941)* | 19.997 | 0.256 | 0.979 | -3.274 | 0.967 | 3.13 | 5.76 | 91.11 |

* indicates that the variable may not be considered statistically different from zero.

TABLE VIII

Empirical Results for Aggregation Level 1 — Department of Defense Procurement; FYs 1964-1973

| Model | $\alpha_1/\beta_1$ (t-value) | $\alpha_2/\beta_2$ (t-value) | SE | CV | $W^2$ | $\bar{\varepsilon}$ | $R^2$ | $U_B$(%) | $U_M$(%) | $U_R$(%) |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 1.1352 (6.45807) | -- | 1337.6723 | 0.095 | 0.988 | 164.0351 | -0.079 | 1.69 | 51.15 | 47.16 |
| R2 | 1.04148 (5.80502) | -- | 1300.869 | 0.093 | 0.989 | 157.8121 | -0.020 | 1.65 | 51.65 | 46.70 |
| R3 | 1.08831 (5.28408) | -0.54829 (-0.96884) | 1123.0638 | 0.080 | 0.991 | 130.8837 | 0.238 | 1.53 | 55.95 | 42.52 |
| A1 | 0.89864 (5.0491) | -- | 1338.204 | 0.106 | 0.995 | 59.8242 | -0.270 | 0.22 | 0.08 | 99.70 |
| A2 | 0.89218 (4.93735) | 0.37134 (0.59054) | 1261.1139 | 0.099 | 0.995 | 60.2131 | -0.128 | 0.26 | 0.16 | 99.58 |
| A3 | gaming variable would not enter F-to-enter = 0.0001 | | | | | | | | | |
| A4 | 0.88020 (4.62435) | 0.39153 (0.63633) | 1246.373 | 0.098 | 0.997 | 40.5099 | -0.103 | 0.12 | 2.16 | 97.72 |

TABLE IX

Empirical Results for Aggregation Level 2 — Navy Procurement Aircraft and Missiles; FYs 1960-1969

| Model | $\alpha_1/\beta_1$ (t-value) | $\alpha_2/\beta_2$ (t-value) | SE | CV | $W^2$ | $\bar{\varepsilon}$ | $R^2$ | $U_B(\%)$ | $U_M(\%)$ | $U_R(\%)$ |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 0.97378 (3.7295) | -- | 537.3110 | 0.221 | 0.956 | 65.4390 | -0.077 | 1.53 | 0.69 | 97.78 |
| R2 | 1.02233 (3.6511) | -- | 607.8696 | 0.241 | 0.950 | 60.0583 | -0.288 | 1.08 | 0.35 | 98.57 |
| R3 | 0.98668 (3.4766) | -0.22076 (-0.2790)* | 586.5718 | 0.233 | 0.976 | 58.1764 | -0.064 | 1.23 | 0.07 | 98.70 |
| A1 | 0.9998 (4.4917) | -- | 410.7917 | 0.160 | 0.978 | 21.275 | 0.493 | 0.31 | 0.91 | 98.78 |
| A2 | 0.9987 (4.0663) | 0.44221 (0.6399)* | 429.4023 | 0.167 | 0.981 | 36.5697 | 0.576 | 1.03 | 1.93 | 97.04 |
| A3 | $(X_t-\beta_0 Y_{t-1})$ would not enter regression | | | | | | | | | |
| A4 | 0.9985 (4.2525) | 0.15213 (0.3075)* | 425.5598 | 0.166 | 0.979 | 31.6774 | 0.522 | 0.69 | 0.16 | 99.15 |

* indicates that the variable may not be considered statistically different from zero.

TABLE X

Empirical Results for Aggregation Level 2 — Air Force Procurement Aircraft; FYs 1953-1969

| Model | $\alpha_1/\beta_1$ (t-value) | $\alpha_2/\beta_2$ (t-value) | SE | CV | $W^2$ | $\bar{\varepsilon}$ | $R^2$ | $U_B$(%) | $U_M$(%) | $U_R$(%) |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 0.88024 (3.3695) | -- | 1152.2673 | 0.303 | 0.917 | 266.6827 | -1.032 | 5.71 | 11.36 | 82.93 |
| R2 | 0.8674 (3.1430) | -- | 1290.041 | 0.339 | 0.896 | 309.5979 | -1.536 | 6.14 | 8.78 | 85.08 |
| R3 | 0.87933 (3.3135) | 0.18015 (0.2428)* | 1188.1726 | 0.312 | 0.918 | 272.1375 | -1.011 | 6.00 | 12.76 | 81.24 |
| A1 | 0.97755 (5.0462) | -- | 582.3652 | 0.155 | 0.978 | 38.2437 | 0.458 | 0.46 | 0.14 | 99.40 |
| A2 | 0.97418 (4.8883) | 0.10566 (0.1978)* | 599.8738 | 0.160 | 0.979 | 42.5834 | 0.464 | 0.58 | 0.00 | 99.42 |
| A3 | 0.9527 (5.2177) | 0.30048 (0.8825)* | 478.735 | 0.127 | 0.985 | 52.6605 | 0.637 | 1.29 | 5.50 | 93.21 |
| A4 | 0.98524 (5.4736) | 0.23058 (0.7612)* | 500.4341 | 0.133 | 0.985 | 60.789 | 0.631 | 1.69 | 8.97 | 89.34 |

* indicates that the variable may not be considered statistically different from zero.

TABLE XI

Empirical Results for Aggregation Level 2 Air Force Procurement Missiles; FYs 1953-1969

| Model | $\alpha_1/\beta_1$ (t-value) | $\alpha_2/\beta_2$ (t-value) | SE | CV | $W^2$ | $\bar{\varepsilon}$ | $R^2$ | $U_B$(%) | $U_M$(%) | $U_R$(%) |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 0.90651 (3.3224) | -- | 527.7134 | 0.325 | 0.908 | 113.8633 | -0.248 | 4.97 | 3.62 | 91.41 |
| R2 | 0.89291 (3.2353) | -- | 546.1875 | 0.336 | 0.902 | 104.6653 | -0.352 | 3.92 | 0.99 | 95.09 |
| R3 | 0.90627 (3.2838) | -0.29964 (-0.41374)* | 539.8943 | 0.332 | 0.910 | 103.6347 | -0.229 | 4.21 | 2.13 | 93.66 |
| A1 | 0.98049 (4.93601) | -- | 266.040 | 0.167 | 0.976 | -0.2047 | 0.743 | 0.00 | 7.57 | 92.43 |
| A2 | 0.98444 (5.0114) | -0.33614 (-0.6693)* | 250.6196 | 0.157 | 0.979 | -7.4669 | 0.772 | 0.09 | 13.54 | 86.37 |
| A3 | 0.95541 (4.98674) | 0.27296 (0.7844)* | 227.8918 | 0.143 | 0.9826 | 9.4862 | 0.812 | 0.18 | 0.71 | 99.11 |
| A4 | 0.98203 (5.0159) | 0.15857 (0.4679)* | 258.3503 | 0.162 | 0.979 | 9.6233 | 0.774 | 0.16 | 1.36 | 98.48 |

* indicates that the variable may not be considered statistically different from zero.

TABLE XII

Empirical Results for Aggregation Level 2 — Army Procurement Missiles and Equipment; FYs 1959-1969

| Model | $\alpha_1/\beta_1$ (t-value) | $\alpha_2/\beta_2$ (t-value) | SE | CV | $W^2$ | $\bar{\varepsilon}$ | $R^2$ | $U_B(\%)$ | $U_M(\%)$ | $U_R(\%)$ |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 1.11101 (3.124) | -- | 1084.3380 | 0.395 | 0.896 | 85.8958 | 0.596 | 0.70 | 3.64 | 94.66 |
| R2 | 1.1244 (3.029) | -- | 1157.4715 | 0.422 | 0.881 | 182.1324 | 0.549 | 2.75 | 0.48 | 96.77 |
| R3 | | $(X_t - X_{t-1})$ would not enter F-to-enter = 0.0001 | | | | | | | | |
| A1 | 0.96879 (5.394) | -- | 324.6877 | 0.119 | 0.990 | 70.3542 | 0.958 | 5.22 | 9.27 | 85.51 |
| A2 | 0.96128 (4.995) | 0.15977 (0.279)* | 319.9294 | 0.117 | 0.990 | 61.3758 | 0.959 | 4.09 | 6.82 | 89.09 |
| A3 | 0.95764 (5.191) | 0.1067 (0.328)* | 305.6720 | 0.112 | 0.991 | 91.7786 | 0.965 | 10.02 | 21.06 | 68.92 |
| A4 | 0.93999 (4.742) | 0.13303 (0.403)* | 298.1608 | 0.109 | 0.992 | 87.4548 | 0.966 | 9.56 | 20.23 | 70.21 |

* indicates that the variable may not be considered statistically different from zero.

Note: Data for FYs 1955-1958 missing.

TABLE XIII

Empirical Results for Aggregation Level 2 — PAMN, PEMA, Air Force Aircraft & Missile Procurement (Pooled); FYs 1970-1971

| Model | $\alpha_1/\beta_1$ (t-value) | $\alpha_2/\beta_2$ (t-value) | SE | CV | $W^2$ | $\bar{\varepsilon}$ | $R^2$ | $U_B$(%) | $U_M$(%) | $U_R$(%) |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 1.02745 (4.911) | -- | 554.8431 | 0.176 | 0.974 | 74.8284 | 0.704 | 1.94 | 2.62 | 95.44 |
| R2 | 0.92585 (4.683) | -- | 550.0350 | 0.174 | 0.974 | 83.4170 | 0.710 | 2.45 | 4.56 | 92.99 |
| R3 | 0.96933 (3.209) | -0.5364 (-0.626)* | 554.5896 | 0.173 | 0.975 | 77.5745 | 0.715 | 2.16 | 3.58 | 94.26 |
| A1 | 0.89869 (7.916) | -- | 170.2147 | 0.060 | 0.995 | 13.7456 | 0.963 | 0.70 | 3.20 | 96.10 |
| A2 | 0.89815 (7.917) | 0.25561 (0.515)* | 164.006 | 0.058 | 0.996 | 11.2513 | 0.965 | 0.50 | 2.01 | 97.49 |
| A3 | gaming variable would not enter F-to-enter = 0.0083 | | | | | | | | | |
| A4 | 0.89969 (7.628) | 0.01913 (0.068)* | 169.8449 | 0.060 | 0.995 | 13.7183 | 0.963 | 0.70 | 3.21 | 96.09 |

* indicates that the variable may not be considered statistically different from zero.

TABLE XIV

Empirical Results for Aggregation Level 3 Procurement Programs; FYs 1970-1971

| Model | $\alpha_1/\beta_1$ (t-value) | $\alpha_2/\beta_2$ (t-value) | SE | CV | $W^2$ | $\bar{\varepsilon}$ | $R^2$ | $U_B(\%)$ | $U_M(\%)$ | $U_R(\%)$ |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 0.99058 (4.029) | -- | 301.5656 | 0.247 | 0.955 | 55.480 | 0.924 | 3.76 | 0.73 | 95.51 |
| R2 | 0.88331 (4.024) | -- | 270.5981 | 0.222 | 0.981 | 22.632 | 0.937 | 0.78 | 0.05 | 99.17 |
| R3 | 0.90335 (3.125) | -0.72999 (-1.022)* | 269.0670 | 0.220 | 0.978 | 26.661 | 0.938 | 1.09 | 0.00 | 98.91 |
| A1 | 0.92744 (6.971) | -- | 88.9874 | 0.079 | 1.000 | -1.672 | 0.992 | 0.04 | 0.47 | 99.49 |
| A2 | 0.94291 (7.471) | 0.33791 (0.888)* | 68.6259 | 0.062 | 0.994 | 7.0301 | 0.995 | 1.17 | 0.87 | 97.96 |
| A3 | 0.93549 (9.036) | -0.2482 (-1.017)* | 49.9793 | 0.044 | 0.998 | 2.2831 | 0.998 | 0.23 | 0.10 | 99.67 |
| A4 | 0.91226 (6.677) | 09.14806 (-0.494)* | 76.910 | 0.068 | 1.000 | -3.2159 | 0.994 | 0.19 | 0.83 | 98.98 |

* indicates that the variable may not be considered statistically different from zero.

TABLE XV

Empirical Results for Aggregation Level 4 Procurement Program Elements (Pooled); FYs 1970-1971

| Model | $\alpha_1/\beta_1$ (t-value) | $\alpha_2/\beta_2$ (t-value) | SE | CV | $W^2$ | $\bar{\varepsilon}$ | $R^2$ | $U_B(\%)$ | $U_M(\%)$ | $U_R(\%)$ |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 0.73779 (3.3999) | -- | 63.7045 | 0.462 | 0.922 | 15.3932 | 0.882 | 6.13 | 0.00 | 93.87 |
| R2 | 0.68508 (3.2514) | -- | 63.9449 | 0.463 | 0.922 | 17.1044 | 0.882 | 7.51 | 0.06 | 92.43 |
| R3 | 0.72507 (2.8489) | -0.31198 (-0.4239) | 64.7964 | 0.456 | 0.924 | 15.9594 | 0.884 | 6.71 | 0.30 | 93.26 |
| A1 | 0.97267 (5.8349) | -- | 28.4292 | 0.225 | 0.984 | -7.4352 | 0.973 | 6.65 | 7.75 | 84.60 |
| A2 | | $(Y_{t-1}-\alpha_1 X_{t-1})$ would not enter regression | | | | | | | | |
| A3 | 0.98832 (6.0263) | -0.20123 (-0.6491) | 26.2914 | 0.200 | 0.987 | -6.8288 | 0.982 | 7.46 | 7.53 | 85.01 |
| A4 | 0.92337 (5.0457) | -0.14279 (-0.5599) | 26.0465 | 0.200 | 0.987 | -6.4346 | 0.982 | 6.75 | 6.94 | 86.31 |

TABLE XVI

Empirical Results for Aggregation Level 4 Procurement Program Elements, Quantity Items; FYs 1970-1971

| Model | $\alpha_1/\beta_1$ (t-value) | $\alpha_2/\beta_2$ (t-value) | SE | CV | $W^2$ | $\bar{\varepsilon}$ | $R^2$ | $U_B(\%)$ | $U_M(\%)$ | $U_R(\%)$ |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 0.59978 (1.569)* | -- | 109.6873 | 1.233 | 0.508 | 43.7354 | 0.135 | 16.51 | 8.74 | 74.75 |
| R2 | 0.57896 (1.533)* | -- | 109.9496 | 1.245 | 0.603 | 44.7296 | 0.615 | 17.19 | 4.86 | 77.95 |
| R3 | $(Y_{t-1}-X_{t-1})$ would not enter F-to-enter = 0.0001 | | | | | | | | | |
| A1 | 0.96248 (5.227) | -- | 24.3495 | 0.304 | 0.969 | -5.5332 | 0.954 | 5.36 | 8.76 | 85.90 |
| A2 | 0.96285 (5.168) | -0.03384 (-0.065)* | 24.3423 | 0.308 | 0.969 | -5.4339 | 0.954 | 5.17 | 8.32 | 86.51 |
| A3 | 0.98987 (4.232) | -0.04514 (-0.170)* | 24.1508 | 0.306 | 0.969 | -5.9949 | 0.955 | 6.40 | 9.60 | 84.00 |
| A4 | 0.97144 (5.062) | -0.02714 (-0.131)* | 24.1364 | 0.301 | 0.969 | -5.9312 | 0.956 | 6.27 | 9.63 | 84.10 |

* indicates that the variable may not be considered statistically different from zero.

TABLE XVII

Empirical Results for Aggregation Level 4 Procurement Program Elements, Non-Quantity Items; FYs 1970-1971

| Model | $\alpha_1/\beta_1$ (t-value) | $\alpha_2/\beta_2$ (t-value) | SE | CV | $W^2$ | $\bar{\varepsilon}$ | $R^2$ | $U_B$(%) | $U_M$(%) | $U_R$(%) |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 0.79656 (3.1534) | -- | 76.339 | 0.372 | 0.926 | 15.241 | 0.889 | 4.38 | 0.05 | 95.57 |
| R2 | 0.73343 (2.9629) | -- | 79.410 | 0.387 | 0.932 | 13.9272 | 0.879 | 3.38 | 0.00 | 96.62 |
| R3 | 0.81783 (2.4334) | 0.2608 (0.2471)* | 76.108 | 0.371 | 0.922 | 15.990 | 0.891 | 4.86 | 0.11 | 95.03 |
| A1 | 0.99046 (10.674) | -- | 8.466 | 0.041 | 0.992 | 1.575 | 0.999 | 3.81 | 2.86 | 93.33 |
| A2 | 1.0061 (5.149) | -0.0952 (-0.251)* | 8.218 | 0.040 | 0.993 | 1.288 | 0.999 | 2.70 | 1.96 | 95.34 |
| A3 | 1.0043 (5.246) | -0.0112 (-0.675)* | 8.395 | 0.041 | 0.993 | 1.533 | 0.999 | 3.67 | 2.74 | 93.59 |
| A4 | 0.99227 (9.185) | 0.00661 (0.0403)* | 8.466 | 0.041 | 0.992 | 1.575 | 0.999 | 3.81 | 2.86 | 93.33 |

* indicates that the variable may not be considered statistically different from zero.

APPENDIX C

DOD PROCUREMENT ($ Millions)

| Fiscal Year | Request | Appropriation |
|---|---|---|
| 1964 | 8,677.73 | 7,985.26 |
| 1965 | 11,116.46 | 10,883.53 |
| 1966 | 13,288.26 | 13,356.21 |
| 1967 | 14,436.73 | 14,646.36 |
| 1968 | 14,364.90 | 13,557.42 |
| 1969 | 15,212.05 | 11,256.84 |
| 1970 | 14,341.46 | 12,467.72 |
| 1971 | 13,492.53 | 12,451.98 |
| 1972 | 14,959.23 | 13,337.10 |
| 1973 | 15,071.27 | 12,064.64 |

SERVICE PROCUREMENT ($ Millions)

| Service | Fiscal Year | Request | Appropriation |
|---|---|---|---|
| Army - Missiles & Equipment | 1953 | 2,544.4 | 1,889.2 |
| | 1954 | 1,070.7 | 2,226.6 |
| | 1955 | * | * |
| | 1956 | * | * |
| | 1957 | * | * |
| | 1958 | * | * |
| | 1959 | 970.1 | 166.9 |
| | 1960 | 1,024.7 | 971.7 |
| | 1961 | 1,337.0 | 1,495.3 |
| | 1962 | 1,803.0 | 2,532.6 |
| | 1963 | 2,555.0 | 2,520.0 |
| | 1964 | 3,202.0 | 2,931.0 |
| | 1965 | 1,779.0 | 1,656.4 |
| | 1966 | 1,223.1 | 1,204.8 |
| | 1967 | 3,311.1 | 3,483.3 |
| | 1968 | 5,581.0 | 5,462.5 |
| | 1969 | 5,626.0 | 5,031.4 |
| | 1970 | 5,069.1 | 4,254.4 |
| | 1971 | 3,226.0 | 2,958.5 |
| | 1972 | 3,719.4 | 3,407.3 |
| | 1973 | 3,439.1 | 3,025.0 |
| Navy - Aircraft and Missiles | 1953 | 124.5 | 113.5 |
| | 1954 | 1,924.2 | 1,222.8 |
| | 1955 | 2,030.8 | 1,944.7 |
| | 1956 | 945.2 | 804.5 |
| | 1957 | 1,703.4 | 1,696.2 |
| | 1958 | 1,852.3 | 1,724.9 |
| | 1959 | 2,083.9 | 2,129.3 |
| | 1960 | 2,114.1 | 2,044.6 |

* Missing

| Service | Fiscal Year | Request | Appropriation |
|---|---|---|---|
| | 1961 | 2,114.9 | 2,144.1 |
| | 1962 | 2,000.0 | 2,680.9 |
| | 1963 | 3,065.0 | 3,834.7 |
| | 1964 | 3,066.0 | 2,889.1 |
| | 1965 | 2,515.8 | 2,496.3 |
| | 1966 | 2,279.8 | 2,272.5 |
| | 1967 | 1,789.9 | 1,789.9 |
| | 1968 | 3,046.0 | 2,939.1 |
| | 1969 | 3,222.0 | 2,574.3 |
| | 1970 | 3,235.0 | 2,620.0 |
| | 1971 | 3,427.7 | 3,117.9 |
| | 1972 | 4,069.1 | 3.955.0 |
| | 1973 | 4,118.6 | 3,696.3 |
| Air Force - Aircraft | 1953 | 8,205.6 | 8,048.0 |
| | 1954 | 4,283.0 | 2,453.7 |
| | 1955 | 2,098.8 | 2,072.4 |
| | 1956 | 4,031.0 | 4,128.8 |
| | 1957 | 3,859.9 | 4,533.1 |
| | 1958 | 4,122.9 | 3,914.9 |
| | 1959 | 4,012.8 | 4,288.4 |
| | 1960 | 4,322.8 | 4,284.6 |
| | 1961 | 2,934.1 | 3,497.2 |
| | 1962 | 3,136.2 | 3,537.2 |
| | 1963 | 3,135.0 | 3,562.4 |
| | 1964 | 3,559.0 | 3,385.6 |
| | 1965 | 3,663.0 | 3,563.7 |
| | 1966 | 3,550.2 | 3,517.0 |
| | 1967 | 3,961.3 | 4,017.3 |
| | 1968 | 5,582.0 | 5,493.4 |
| | 1969 | 4,612.0 | 3,860.0 |
| | 1970 | 3,775.2 | 3,405.8 |
| | 1971 | 3,314.9 | 3,219.3 |
| | 1972 | 3,116.5 | 2,942.3 |
| | 1973 | 3,255.7 | 2,682.3 |

| Service | Fiscal Year | Request | Appropriation |
| --- | --- | --- | --- |
| Air Force - | 1953 | 3,012.1 | 2,903.8 |
| Missiles | 1954 | 1,509.5 | 936.9 |
| | 1955 | 830.2 | 812.7 |
| | 1956 | 1,449.5 | 1,475.4 |
| | 1957 | 1,483.9 | 1,695.5 |
| | 1958 | 1,578.7 | 1,500.7 |
| | 1959 | 1,722.1 | 1,394.2 |
| | 1960 | 1,832.1 | 2,540.5 |
| | 1961 | 2,124.9 | 1,837.6 |
| | 1962 | 1,975.2 | 1,928.7 |
| | 1963 | 2,500.0 | 2,459.0 |
| | 1964 | 2,177.0 | 2,141.9 |
| | 1965 | 1,730.0 | 1,730.0 |
| | 1966 | 796.1 | 796.1 |
| | 1967 | 1,189.5 | 1,189.5 |
| | 1968 | 1,343.0 | 1,340.0 |
| | 1969 | 1,768.0 | 1,720.2 |
| | 1970 | 1,486.4 | 1,448.1 |
| | 1971 | 1,530.6 | 1,427.2 |
| | 1972 | 1,837.4 | 1,683.7 |
| | 1973 | 1,816.8 | 1,705.0 |

PROCUREMENT - PROGRAMS ($ Millions)

| Programs | FY 1970 Request | FY 1970 Appropriation | FY 1971 Request | FY 1971 Appropriation |
|---|---|---|---|---|
| AIRCRAFT | | | | |
| Army | 941.5 | 554.4 | 296.9 | 254.6 |
| Navy & Marine Corps | 2,409.2 | 1,826.2 | 2,487.7 | 2,126.5 |
| Air Force | 3,775.2 | 3,405.8 | 3,314.9 | 3,219.3 |
| MISSILES | | | | |
| Army | 957.7 | 831.9 | 1,094.6 | 983.8 |
| Navy | 851.3 | 818.8 | 983.0 | 905.5 |
| Air Force | 1,486.4 | 1,448.1 | 1,530.6 | 1,427.2 |
| Marine Corps | 20.1 | 3.4 | 27.6 | 12.8 |
| TRACKED COMBAT VEHCILES | | | | |
| Army | 305.8 | 201.1 | 207.2 | 197.5 |
| Marine Corps | 37.7 | 37.7 | 48.7 | 47.4 |
| NEW SHIP CONSTRUCTION | | | | |
| Navy | 1,945.5 | 1,912.3 | 2,578.9 | 2,465.4 |
| OTHER WEAPONS | | | | |
| Army | * | * | 68.2 | 62.0 |
| Navy | * | * | 2.8 | 2.8 |
| Marine Corps | * | * | 4.4 | 4.4 |

* New Program Beginning FY 71

## PROGRAM ELEMENTS - PROCUREMENT ($ Millions)

| | FY 1970 | | FY 1971 | | |
|---|---|---|---|---|---|
| P.E. | REQT | APPR | REQT | APPR | TYPE P.E. |
| 0101 | 56.3 | 56.3 | 41.6 | 26.6 | QI |
| 0102 | 49.2 | 49.2 | 37.9 | 29.6 | QI |
| 0103 | 0.0 | 86.0 | 37.0 | 32.6 | QI |
| 0104 | 68.4 | 68.4 | 64.2 | 62.0 | QI |
| 0106 | 69.5 | 65.1 | 38.6 | 37.2 | NQI |
| 0110 | 8.2 | 11.6 | 9.2 | 5.3 | NQI |
| 0111 | 227.4 | 160.7 | 50.6 | 48.3 | NQI |
| 0206 | 42.3 | 42.3 | 96.2 | 64.0 | QI |
| 0215 | 0.0 | 0.0 | 79.0 | 0.0 | QI |
| 0217 | 0.0 | 0.0 | 92.3 | 0.0 | QI |
| 0218 | 0.0 | 0.0 | 20.0 | 43.0 | NQI |
| 0222 | 325.9 | 327.6 | 255.9 | 248.8 | NQI |
| 0223 | 568.5 | 495.6 | 447.4 | 453.0 | NQI |
| 0305 | 11.2 | 11.2 | 10.3 | 9.2 | QI |
| 0306 | 599.8 | 566.0 | 283.0 | 283.0 | QI |
| 0307 | 71.4 | 74.4 | 200.5 | 200.5 | NQI |
| 0309 | 8.0 | 5.9 | 4.5 | 4.5 | NQI |
| 0314 | 28.1 | 6.6 | 39.3 | 39.3 | QI |
| 0315 | 53.7 | 53.7 | 46.6 | 41.6 | QI |
| 0317 | 550.2 | 506.7 | 537.4 | 526.4 | NQI |
| 0320 | 42.0 | 40.0 | 32.0 | 32.0 | NQI |
| 0321 | 38.5 | 35.5 | 27.5 | 27.5 | NQI |
| 0323 | 101.3 | 91.3 | 92.1 | 92.1 | NQI |

CODE:

01=Army, 02-Navy, 03=Air Force

Example: 0101 = Army, Program Element 01

DOD RDT&E ($ Millions)

| Fiscal Year | Request | Appropriation |
|---|---|---|
| 1953 | 1,050.7 | 1,035.0 |
| 1954 | 1,086.9 | 843.6 |
| 1955 | 847.0 | 1,182.9 |
| 1956 | 1,342.2 | 1,342.2 |
| 1957 | 1,497.0 | 1,612.0 |
| 1958 | 1,566.0 | 1,566.0 |
| 1959 | 1.831.0 | 2,063.0 |
| 1960 | 2,767.4 | 3,211.5 |
| 1961 | 3,544.7 | 3,812.8 |
| 1962 | 4,034.4 | 4,907.9 |
| 1963 | 6,242.0 | 6,427.6 |
| 1964 | 6,680.9 | 6,379.4 |
| 1965 | 6,068.8 | 5,838.9 |
| 1966 | 6,074.8 | 5,964.3 |
| 1967 | 6,332.9 | 6,411.2 |
| 1968 | 6,701.5 | 6,592.0 |
| 1969 | 7,173.0 | 7,234.2 |
| 1970 | 7,622.2 | 6,843.8 |
| 1971 | 6,824.9 | 6,545.4 |
| 1972 | 7,399.9 | 7,124.7 |
| 1973 | 8.201.7 | 7,500.2 |

## SERVICE RDT&E ($ Millions)

| Service | Fiscal Year | Request | Appropriation |
|---|---|---|---|
| ARMY | 1953 | 450.0 | 440.0 |
| | 1954 | 475.0 | 345.0 |
| | 1955 | 355.0 | 345.0 |
| | 1956 | 330.0 | 333.0 |
| | 1957 | 410.0 | 410.0 |
| | 1958 | 400.0 | 400.0 |
| | 1959 | 471.0 | 498.7 |
| | 1960 | 1,046.5 | 1,035.7 |
| | 1961 | 1,041.7 | 1,041.3 |
| | 1962 | 1,130.4 | 1,203.2 |
| | 1963 | 1,329.0 | 1,319.5 |
| | 1964 | 1,474.6 | 1,390.2 |
| | 1965 | 1,401.5 | 1,344.1 |
| | 1966 | 1,442.7 | 1,410.6 |
| | 1967 | 1,522.2 | 1,531.9 |
| | 1968 | 1,544.0 | 1,514.2 |
| | 1969 | 1,661.9 | 1,522.6 |
| | 1970 | 1,849.5 | 1,596.8 |
| | 1971 | 1,717.9 | 1,618.2 |
| | 1972 | 1,951.5 | 1,839.5 |
| | 1973 | 2,122.7 | 1,829.0 |

| Service | Fiscal Year | Request | Appropriation |
|---|---|---|---|
| NAVY | 1953 | 75.7 | 70.0 |
| | 1954 | 74.9 | 58.6 |
| | 1955 | 61.0 | 419.9 |
| | 1956 | 439.2 | 439.2 |
| | 1957 | 477.0 | 492.0 |
| | 1958 | 505.0 | 505.0 |
| | 1959 | 641.0 | 821.3 |
| | 1960 | 970.9 | 1,015.2 |
| | 1961 | 1,169.0 | 1,218.6 |
| | 1962 | 1,267.0 | 1,301.5 |
| | 1963 | 1,474.0 | 1,475.9 |
| | 1964 | 1,578.4 | 1,530.5 |
| | 1965 | 1,456.4 | 1,397.2 |
| | 1966 | 1,478.2 | 1,444.2 |
| | 1967 | 1,752.5 | 1,762.4 |
| | 1968 | 1,863.9 | 1,826.5 |
| | 1969 | 2,146.4 | 2,141.3 |
| | 1970 | 2,211.5 | 2,186.4 |
| | 1971 | 2,197.3 | 2,165.1 |
| | 1972 | 2,431.4 | 2,372.3 |
| | 1973 | 2,816.8 | 2,548.3 |

| Service | Fiscal Year | Request | Appropriation |
|---|---|---|---|
| AIR FORCE | 1953 | 525.0 | 525.0 |
| | 1954 | 537.0 | 440.0 |
| | 1955 | 431.0 | 418.1 |
| | 1956 | 570.0 | 570.0 |
| | 1957 | 610.0 | 710.0 |
| | 1958 | 661.0 | 661.0 |
| | 1959 | 719.0 | 743.0 |
| | 1960 | 750.0 | 1,159.9 |
| | 1961 | 1,334.0 | 1,552.9 |
| | 1962 | 1,637.0 | 2,403.3 |
| | 1963 | 3,439.0 | 3,632.1 |
| | 1964 | 3,627.9 | 3,458.7 |
| | 1965 | 3,210.9 | 3,117.3 |
| | 1966 | 3,153.9 | 3,109.5 |
| | 1967 | 3,058.2 | 3,116.9 |
| | 1968 | 3,293.6 | 3,251.2 |
| | 1969 | 3,364.7 | 3,570.3 |
| | 1970 | 3,561.2 | 3,060.6 |
| | 1971 | 2,909.7 | 2,762.1 |
| | 1972 | 3,017.0 | 2,912.9 |
| | 1973 | 3,262.2 | 3,122.9 |

PROGRAMS RDT&E ($ Millions)

| Service | Program | FY 1970 Reqt. | FY 1970 Appr. | FY 1971 Reqt. | FY 1971 Appr. |
|---|---|---|---|---|---|
| ARMY | | | | | |
| | Military Sciences | 182.4 | 163.3 | 176.2 | 166.6 |
| | Aircraft and Related Equipment | 127.1 | 71.5 | 110.2 | 106.2 |
| | Missiles and Related Equipment | 914.9 | 897.4 | 896.4 | 869.0 |
| | Military Astronautics | 14.0 | 10.0 | 10.7 | 8.5 |
| | Ordnance, Combat Vehicles, and Related Equip. | 193.1 | 163.0 | 153.2 | 144.9 |
| | Other Equipment | 130.7 | 130.7 | 317.8 | 297.8 |
| | Programwide Management & Support | 54.1 | 48.1 | 52.3 | 52.3 |
| NAVY | | | | | |
| | Military Sciences | 160.1 | 139.8 | 142.2 | 135.3 |
| | Aircraft and Related Equipment | 577.3 | 799.7 | 694.0 | 735.8 |
| | Missiles and Related Equipment | 564.6 | 459.3 | 494.3 | 484.6 |
| | Military Astronautics | 24.0 | 19.7 | 29.1 | 28.1 |
| | Ships & Small Craft Related Equip. | 345.2 | 291.5 | 377.5 | 350.2 |
| | Ordnance, Combat Vehicles, and Related Equip. | 109.1 | 95.8 | 89.0 | 89.0 |
| | Other Equipment | 280.0 | 252.9 | 226.7 | 223.4 |
| | Programwide Management & Support | 151.2 | 141.2 | 144.5 | 143.0 |
| AIR FORCE | | | | | |
| | Military Sciences | 158.7 | 136.4 | 134.6 | 134.3 |
| | Aircraft and Related Equipment | 663.0 | 608.9 | 831.3 | 765.7 |
| | Missiles and Related Equipment | 976.9 | 912.9 | 762.8 | 708.3 |
| | Military Astronautics | 1,068.0 | 751.7 | 437.7 | 437.7 |
| | Ordnance, Combat Vehicles, and Related Equip. | * | * | 78.3 | 78.3 |
| | Other Equipment | 385.2 | 349.2 | 437.9 | 435.7 |
| | Programwide Management & Support | 309.4 | 301.5 | 305.4 | 305.4 |

* New Program

PROGRAM ELEMENTS - RDT&E ($ Millions)

| P.E. | FY 1970 REQT | FY 1970 APPR | FY 1971 REQT | FY 1971 APPR |
|---|---|---|---|---|
| 23619A | 44.9 | 30.0 | 36.0 | 36.0 |
| 23625A | 16.5 | 0.0 | 17.6 | 17.6 |
| 28012A | 14.2 | 11.7 | 12.0 | 6.0 |
| 33111A | 10.0 | 6.0 | 7.6 | 5.4 |
| 61101&2A | 97.1 | 80.5 | 80.1 | 76.3 |
| 63302A | 75.0 | 60.0 | 89.3 | 83.1 |
| 63304A | 141.0 | 141.0 | 158.0 | 138.0 |
| 63767A | 21.0 | 16.0 | 14.0 | 0.0 |
| 64206A | 12.5 | 1.5 | 0.2 | 0.2 |
| 64303A | 4.3 | 2.8 | 2.9 | 2.9 |
| 64501A | 0.5 | 0.5 | 1.1 | 0.0 |
| 64601A | 11.9 | 4.9 | 6.1 | 6.1 |
| 11221N | 223.7 | 202.6 | 122.7 | 122.7 |
| 11314N | 41.0 | 20.9 | 19.0 | 19.0 |
| 24122N | 274.0 | 274.0 | 324.2 | 319.0 |
| 25603N | 12.9 | 8.0 | 23.3 | 23.3 |
| 61102N | 120.5 | 105.5 | 106.6 | 101.6 |
| 63314N | 20.0 | 10.0 | 44.0 | 44.0 |
| 64202N | 165.4 | 140.4 | 208.0 | 266.0 |
| 64214N | 5.0 | 2.0 | 10.0 | 10.0 |
| 64303N | 67.9 | 35.0 | 75.0 | 75.0 |
| 12410F | 60.0 | 40.0 | 87.0 | 87.0 |
| 27214F | 15.0 | 2.0 | 0.0 | 0.0 |
| 34111F | 159.8 | 259.8 | 172.8 | 172.8 |
| 35110F | 37.2 | 36.2 | 37.0 | 37.0 |
| 35121F | 525.3 | 125.3 | 0.0 | 0.0 |
| 41214F | 3.0 | 1.5 | 0.0 | 0.0 |
| 61101F | 5.3 | 4.3 | 5.0 | 5.0 |
| 61102F | 94.9 | 80.7 | 78.3 | 78.3 |
| 62101F | 11.0 | 9.5 | 8.0 | 8.0 |
| 62102F | 25.8 | 23.3 | 23.0 | 23.0 |

| P.E. | FY 1970 REQT | FY 1970 APPR | FY 1971 REQT | FY 1971 APPR |
|---|---|---|---|---|
| 62203F | 30.8 | 26.6 | 27.0 | 27.0 |
| 62204F | 50.1 | 46.0 | 44.0 | 44.0 |
| 62302F | 28.7 | 26.7 | 25.0 | 25.0 |
| 63202F | 9.0 | 8.0 | 8.0 | 8.0 |
| 63204F | 1.0 | 0.0 | 2.0 | 0.0 |
| 63214F | 12.0 | 8.0 | 5.0 | 5.0 |
| 63225F | 17.1 | 10.0 | 33.6 | 0.0 |
| 63229F | 18.5 | 2.5 | 2.5 | 0.0 |
| 63311F | 121.4 | 107.0 | 105.0 | 100.0 |
| 63723F | 2.5 | 1.0 | 2.0 | 2.0 |
| 64211F | 12.0 | 2.0 | 27.9 | 27.9 |
| 64307F | 50.0 | 25.0 | 0.0 | 0.0 |
| 64308F | 84.7 | 75.1 | 46.0 | 46.0 |
| 64723F | 2.0 | 1.0 | 2.0 | 2.0 |
| 65101F | 15.6 | 12.6 | 11.0 | 11.0 |
| 65102F | 1.6 | 1.5 | 1.5 | 1.5 |
| 65301F | 68.5 | 63.5 | 67.5 | 67.5 |
| 65302F | 160.9 | 155.9 | 118.0 | 118.0 |
| 65705F | 23.0 | 20.5 | 19.5 | 19.5 |
| 65706F | 12.5 | 11.2 | 9.0 | 9.0 |
| 65806F | 183.0 | 175.0 | 170.9 | 170.9 |

## BIBLIOGRAPHY


1. Byrne, R.F., and others (eds.), Studies in Budgeting, North - Holland Publishing, 1971.

2. Capra, J.R., An Analysis of Data Describing Congressional Responses to DOD Budget Requests, Ph.D. Thesis, Naval Postgraduate School, Monterey, 1974.

3. Center for Naval Analysis Memorandum Serial (RAD) 100-71, A Procedure For Comparing Estimates and Actuals, by J.E. Buchanan, 10 August 1971.

4. Center for Naval Analysis Report 644-73, Navy Responses to Changes in the Defense Resource Planning Process, by H.E. Kanter and T.E. Anger, March, 1973.

5. Chow, G.C., "Tests of Equality Between Sets of Coefficients In Two Linear Regressions," Econometrica, v. 28, 1960.

6. Conover, W.J., Practical Nonparametric Statistics, Wiley, 1971.

7. Crecine, J.P. and Fisher, G., On Resource Allocation Processes In The U.S. Department of Defense, an Institute of Public Studies Discussion Paper No. 31, October, 1971.

8. Croxton, F.E., Cowden, D.J., and Klein, S., Applied General Statistics, Prentice-Hall, 1960.

9. Congressional Action on FY __ Budget Request by Appropriation Title and Item, Department of Defense Appropriation Bill, Office of the Assistant Secretary of Defense (Comptroller)(Fiscal years 1971-1973 available for all budget categories).

10. Cyert, R.M. and March, J.G., A Behavioral Theory of the Firm, Prentice-Hall, 1963.

11. Davis, O.A., Dempster, A.H., and Wildavsky, A., "A Theory of the Budgetary Process," The American Political Science Review, v. 60, p. 529-547, September, 1966.

12. Department of Defense Appropriations, Research, Development, Test and Evaluation (Part 4) and Procurement (Part 7), Hearings before a Subcommittee of the Committee on Appropriations, House of Representatives, U.S. Government Printing Office, Washington, 1972.

13. Department of Defense Appropriations, Part 3: Department of the Navy, Senate Hearings before the Committee on Appropriations, U.S. Government Printing Office, Washington, 1972.

14. Dixon, W.J. and Massey, F.J., Jr., Introduction to Statistical Analysis, p. 193-215, McGraw-Hill, 1969.

15. Dixon, W.J., Biomedical Computer Programs, University of California Press, Berkeley and Los Angeles, 1968.

16. Draper, N. and Smith, H., Applied Regression Analysis, Wiley, 1966.

17. Durbin, J. and Watson, G.S., Testing for Serial Correlation in Least-Squares Regression Analysis, Biometrika, V. 37, 1951.

18. Emery, F.E. and Trist, E.L., "The Causal Texture of Organizational Environments," Readings in Organization Theory: A Behavioral Approach, Hill and Egan, 1967.

19. Fenno, R.F., Jr., "The House Appropriations Committee as a Political System: The Problem of Integration," The American Political Science Review, V. 56, p. 310-324, June, 1962.

20. Fenno, R.F., Jr., The Power of The Purse: Appropriation Politics in Congress, Little, Brown, and Company, 1966.

21. Goldberger, A.S., Econometric Theory, Wiley, 1964.

22. Harris, J.P., Congressional Control of Administration, The Brooking Institute, 1964.

23. Hitch, C.J., Decision Making For Defense, University of California Press, 1965.

24. Johnson, R.W., A Model of Federal Agency Budgetary Behavior: Agency Requests as a Function of Environmental Constraints, paper prepared for the 1972 Annual Meeting of the Public Choice Society, May 3-6, 1972.

25. Johnston, J., Econometric Methods, McGraw-Hill, 1972.

26. Kanter, A., "Congress and the Defense Budget 1960-1970," The American Political Science Review, V. 66, p. 129-143, March, 1972.

27. Korb, L.J., "Congressional Impact on Defense Spending, 1962-1973: The Programmatic and Fiscal Hypotheses," prepared for delivery at the 1973 Annual Meeting of the American Political Science Association, Jung Hotel, New Orleans, Louisiana, September 4-8.

28. Lukenas, L.A., An Analysis of the Budgetary Behavior of the House Appropriations Committee on Defense Procurement, Master's Thesis, Naval Postgraduate School, Monterey, June 1974.

29. Lyden, F.J. and Miller, E.G., Planning, Programming, Budgeting, Markham, 1972.

30. Merton, R., "Bureaucratic Structure and Personality," Social Forces, v. 18, University of North Carolina Press, 1940.

31. Natchez, P.B. and Bupp, I.C., "Policy and Priority in the Budgetary Process," The American Political Science Review, v. 62, p. 951-963, September, 1973.

32. Parsons, T., The Structure of Social Actions, McGraw-Hill, 1937.

33. Rand Corporation, Military Equipment Cost Analysis, p. 33-77, June, 1971.

34. Sapolsky, H.M., The Polaris System Development, Harvard University Press, 1972.

35. Smith, B.L.R., "Communications to the Editor," The American Political Science Review, v. 61, March, 1967.

36. Stromberg, J.L., The Internal Mechanisms of the Defense Budget Process; Fiscal 1953-1968, Rand Corporation, 1970.

37. Summary of Fiscal Year DOD Authorization and Appropriations, printed for use of Senate Committee on Armed Services, Committee Print Table (Fiscal years 1970, 1971, and 1973 for Procurement and RDT&E available).

38. The Budget of the United States Government; Fiscal Years 1953-1973, U.S. Government Printing Office.

39. Theil, H., Applied Economic Forecasting, North-Holland, 1966.

40. Theil, H., Principles of Econometrics, Wiley, 1971.

41. Wildavsky, A., The Politics of the Budgetary Process, Little, Brown, and Company, 1964.

42. Zehna, P.W., Probability Distributions and Statistics, Allyn and Bacon, 1970.

## INITIAL DISTRIBUTION LIST

| | | No. Copies |
|---|---|---|
| 1. | Defense Documentation Center<br>Cameron Station<br>Alexandria, Virginia 22314 | 2 |
| 2. | Library, Code 0212<br>Naval Postgraduate School<br>Monterey, California 93940 | 2 |
| 3. | Chief of Naval Personnel<br>Pers 11b<br>Department of the Navy<br>Washington, D.C. 20370 | 1 |
| 4. | Department Chairmen , Code 55<br>Department of Operations Research<br>and Administrative Sciences<br>Naval Postgraduate School<br>Monterey, California 93940 | 1 |
| 5. | Dr. James R. Capra<br>7218 Delfield Street<br>Chevy Chase, Maryland 20015 | 1 |
| 6. | Adjunct Professor Robert R. Judson, Code 55Ju<br>Department of Operations Research<br>and Administrative Sciences<br>Naval Postgraduate School<br>Monterey, California 93940 | 2 |
| 7. | Asst. Professor James Hartman, Code 55Hh<br>Department of Operations Research<br>and Administrative Sciences<br>Naval Postgraduate School<br>Monterey, California 93940 | 1 |
| 8. | Professor Edward Lawrence, Code 56Lo<br>Department of Government and Humanities<br>Naval Postgraduate School<br>Monterey, California 93940 | 1 |
| 9. | LT Stephen C. Wood, USN<br>1135 Leahy Road<br>Monterey, California 93940 | 2 |

Thesis 157292
W8217 Wood
c.1
Modelling Congressional decision making for defense spending.